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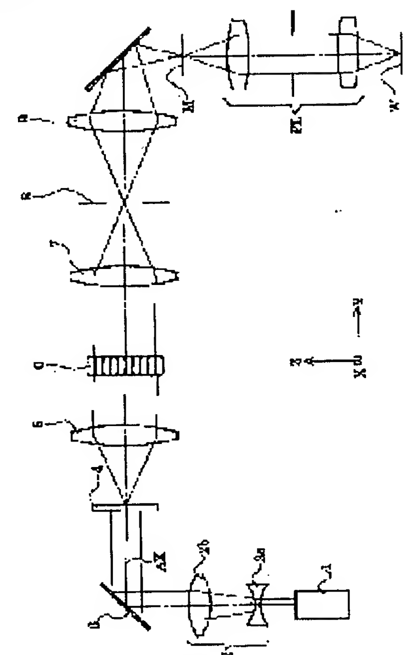
(54) ILLUMINATING OPTICAL DEVICE AND ALIGNER PROVIDED THEREWITH

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an illuminating optical device which can change the conditions of illumination almost continuously without substantially losing the quantity of light in a wave front split optical integrator.
SOLUTION: An illuminating optical device for illuminating a surface (M) to be irradiated on the basis of a luminous flux from a light source (1) is provided with a wave front split optical integrator (6), which is arranged in an optical path between the light source and the surface to be irradiated and has a multitude of two-dimensionally arranged microscopic lens elements, and a light-leading optical system (7) arranged in an optical path between the optical integrator and the surface to be irradiated. A prescribed shape of a secondary light source, which is used as a virtual image, is formed at the position of the incident surface of the optical integrator via a relay optical system (5).



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CLAIMS

[Claim(s)]
[Claim 1] In the illumination-light study equipment for illuminating an irradiated plane based on the flux of light from the light source The optical integrator of the wavefront-splitting mold which has the microlens element of a large number which have been arranged in the optical path between said light sources and said irradiated planes, and were arranged two-dimensional, Illumination-light study equipment characterized by having the light guide optical system arranged in the optical path between said optical integrators and said irradiated planes, and forming the secondary light source of the predetermined configuration as a virtual image in the plane-of-incidence location of said optical integrator.
[Claim 2] Whenever [maximum angle-of-incidence / of the incoming beams to said optical integrator] is illumination-light study equipment according to claim 1 characterized by being set up so that the injection side of said optical integrator may be illuminated by 60% or more of ratio.
[Claim 3] The flux of light sensing element for changing into the flux of light which is arranged in the optical path between said light sources and said optical integrators, and has the flux of light or the optical predetermined intensity distribution of said light source which has a predetermined cross-section configuration for the parallel flux of light mostly, It is arranged in the optical path between said flux of light sensing elements and said optical integrators. Illumination-light study equipment according to claim 1 or 2 characterized by having further the relay optical system for forming said secondary light source as a virtual image in said plane-of-incidence location of said optical integrator based on the flux of light through said flux of light sensing element.
[Claim 4] Said flux of light sensing element is arranged near the before [said relay optical system] side focal plane. The injection side location of said optical integrator It is arranged near the backside [said relay optical system] focal plane. The injection side of said optical integrator It is optically arranged mostly with said flux of light sensing element through said relay optical system conjugate. The plane of incidence of said optical integrator Illumination-light study equipment according to claim 3 characterized by being optically arranged mostly with said irradiated plane through said light guide optical system and said optical integrator conjugate.
[Claim 5] It is illumination-light study equipment according to claim 4 characterized by being constituted as variable power optical system in which said relay optical system has an adjustable focal distance in order to change the magnitude of said whole secondary light source formed in the plane-of-incidence location of said optical integrator as a virtual image.
[Claim 6] So that the injection side of said optical integrator may be illuminated by 80% or more of ratio When set magnitude for a light emitting part of said flux of light sensing element to d, the focal distance of said relay optical system is set to fr, the focal distance of each microlens element which constitutes said optical integrator is set to fe and magnitude of each microlens element is set to de, Illumination-light study equipment according to claim 4 or 5 characterized by satisfying the conditions of d> 0.8 (fr/fe) and de.
[Claim 7] Illumination-light study equipment according to claim 6 characterized by having the light emitting part part modification means for changing magnitude d for a light emitting part of said flux of light sensing element.
[Claim 8] Said light emitting part part modification means is illumination-light study equipment according to claim 7 characterized by being arranged at the light source side of said flux of light sensing element, and having an afocal zoom lens for adjusting the magnitude of the cross section of the flux of light which carries out incidence to said flux of light sensing element.
[Claim 9] Said flux of light sensing element is illumination-light study equipment given in claim 3 characterized by having a diffracted-light study component, a minute prism array, or a micro fly eye lens thru/or any 1 term of 8.

[Claim 10] Illumination-light study equipment given in claim 3 characterized by moving said flux of light sensing element and said optical integrator in accordance with a criteria optical axis in order to adjust the scale-factor component of lighting TERESEN according to a switch of lighting conditions thru/or any 1 term of 9.
[Claim 11] The flux of light sensing element for changing into the flux of light which is arranged in the optical path between said light sources and said optical integrators, and has the flux of light or the optical predetermined intensity distribution of said light source which has a predetermined cross-section configuration for the parallel flux of light mostly, The 1st relay optical system for leading the flux of light which has been arranged in the optical path between said flux of light sensing elements and said optical integrators, and minded said flux of light sensing element to a predetermined side, The flux of light emission component for making the flux of light which it was positioned in said predetermined side and carried out incidence through said 1st relay optical system emit, It is arranged in the optical path between said flux of light emission components and said optical integrators. Illumination-light study equipment according to claim 1 or 2 characterized by having the 2nd relay optical system which makes conjugate optically said flux of light emission component and injection side location of said optical integrator mostly.
[Claim 12] It is illumination-light study equipment according to claim 11 characterized by arranging said flux of light sensing element near the before [said 1st relay optical system] side focal plane, and arranging said flux of light emission component near the backside [said 1st relay optical system] focal plane.
[Claim 13] It is illumination-light study equipment according to claim 12 characterized by being constituted as variable power optical system in which said 1st relay optical system has an adjustable focal distance in order to change the magnitude of said whole secondary light source formed in the plane-of-incidence location of said optical integrator as a virtual image.
[Claim 14] When set whenever [maximum angle-of-emergence / of the injection flux of light from said flux of light emission component] to thetab, the image formation scale factor of said 2nd relay optical system is set to beta, the focal distance of each microlens element which constitutes said optical integrator is set to fe and magnitude of each microlens element is set to de so that the injection side of said optical integrator may be illuminated by 80% or more of ratio, it is thetab>0.8 and sin-1 (|beta| and de/fe).
Illumination-light study equipment according to claim 12 or 13 characterized by satisfying ******.
[Claim 15] It is illumination-light study equipment according to claim 14 characterized by setting [whenever / maximum incident angle / of the incoming beams to said flux of light emission component] up thetaa small substantially rather than thetab whenever [said maximum angle-of-emergence] in order to suppress fluctuation of thetab whenever [maximum angle-of-emergence / of the injection flux of light from said flux of light emission component accompanying change of the focal distance of said 1st relay optical system].
[Claim 16] Said flux of light sensing element and said flux of light emission component are illumination-light study equipment given in claim 11 characterized by having a diffracted-light study component, a minute prism array, or a micro fly eye lens thru/or any 1 term of 15.
[Claim 17] Illumination-light study equipment given in claim 11 characterized by having the include-angle flux of light means forming for being arranged in the optical path between said light sources and said flux of light sensing elements, changing the flux of light from said light source into the flux of light which has two or more include-angle components to a criteria optical axis, and carrying out incidence to said flux of light sensing element thru/or any 1 term of 16.
[Claim 18] The 1st optical system for being arranged in the optical path between said flux of light sensing elements and said 1st relay optical system, condensing the flux of light from said flux of light sensing element, and carrying out incidence to the symmetry from across to the 2nd predetermined side mostly to a criteria optical axis, It has 2 optical integrator. the [of the wavefront-splitting mold for plane of incidence being arranged near said 2nd predetermined side, and forming the a large number light source based on the flux of light from said 1st optical system] -- the numerical aperture of the injection flux of light from said flux of light sensing element -- the [said] -- illumination-light study equipment given in claim 11 characterized by being set up more greatly than the numerical aperture of the flux of light from said a large number light source formed by 2 optical integrator thru/or any 1 term of 16.
[Claim 19] It is arranged in the optical path between said flux of light sensing elements and said 1st relay optical system, and the flux of light from said flux of light sensing element is condensed. The 1st optical system for carrying out incidence to the symmetry from across to the 2nd predetermined side mostly to a criteria optical axis, Illumination-light study equipment given in claim 11 characterized by having been arranged in the optical path of said 1st optical system, and having the modification component whenever [for changing whenever /

incident angle / of the incoming beams to said 2nd predetermined side / incident angle] thru/or any 1 term of 16.

[Claim 20] A modification component is illumination-light study equipment according to claim 19 characterized by having the aspect ratio modification component which changes the aspect ratio of said incoming beams in order to change whenever [incident angle / which met in the predetermined direction of the incoming beams to said 2nd predetermined side] whenever [said incident angle].

[Claim 21] Illumination-light study equipment given in claim 11 characterized by moving said flux of light emission component and said optical integrator in accordance with a criteria optical axis in order to adjust the scale-factor component of lighting TERESEN according to a switch of lighting conditions thru/or any 1 term of 20.

[Claim 22] Between the multi-light source means forming for forming much light sources based on the flux of light from said light source, the flux of light of the 1st group which forms the light source of the 1st group at least among the light sources of said large number, and the flux of light of the 2nd group which forms the light source of the 2nd group Illumination-light study equipment given in claim 1 characterized by having the phase contrast grant means for giving predetermined phase contrast between the flux of light of said 1st group, and the flux of light of said 2nd group by giving a short optical-path-length difference more substantially than the time coherence length of light thru/or any 1 term of 21.

[Claim 23] The aligner characterized by having illumination-light study equipment given in claim 1 thru/or any 1 term of 22, and the projection optics for carrying out projection exposure of the pattern of the mask set as said irradiated plane to up to a photosensitive substrate.

[Claim 24] The manufacture approach of the micro device characterized by including the exposure process which exposes the pattern of said mask on said photosensitive substrate with an aligner according to claim 23, and the development process which develops said photosensitive substrate exposed by said exposure process.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the suitable illumination-light study equipment for the aligner for manufacturing micro devices, such as a semiconductor device, an image sensor, a liquid crystal display component, and the thin film magnetic head, at a lithography process especially about the aligner equipped with illumination-light study equipment and this illumination-light study equipment.
[0002]
[Description of the Prior Art] In this kind of typical aligner, the flux of light injected from the light source carries out incidence to a fly eye lens through relay optical system, and forms the secondary light source which becomes an after that side focal plane from much light sources. After the flux of light from the secondary light source is restricted through the aperture diaphragm arranged near the backside [a fly eye lens] focal plane, incidence of it is carried out to a condenser lens. An aperture diaphragm restricts to the configuration of the secondary light source, the configuration of a request of magnitude, or magnitude according to desired lighting conditions (exposure conditions).
[0003] The flux of light condensed by the condenser lens illuminates in superposition the mask with which the predetermined pattern was formed. Image formation of the light which penetrated the pattern of a mask is carried out on a wafer through projection optics. In this way, on a wafer, projection exposure (imprint) of the mask pattern is carried out. In addition, it is indispensable to integrate highly the pattern formed in the mask and to imprint this detailed pattern correctly on a wafer to acquire uniform illumination distribution on a wafer.
[0004] In recent years, the technique of changing the coherency sigma of lighting (sigma value = the pupil diameter of the diameter of an aperture diaphragm / projection optics or incidence side numerical aperture of the injection side numerical aperture / projection optics of a sigma value = illumination-light study system) attracts attention by changing the magnitude of opening (light transmission section) of the aperture diaphragm arranged at the injection side of a fly eye lens. Moreover, by setting up the configuration of opening of the aperture diaphragm arranged at the injection side of a fly eye lens the shape of zona orbicularis, and in the shape of 4 holes (the shape of namely, 4 poles), the configuration of the secondary light source formed of a fly eye lens is restricted the shape of zona orbicularis, and in the shape of 4 poles, and the technique of raising the depth of focus and resolution of projection optics attracts attention.
[0005] By the way, if only the magnitude of opening of an aperture diaphragm is changed and a sigma value is changed, without changing the magnitude of the secondary light source formed of a fly eye lens, quantity of light loss will occur in an aperture diaphragm. The technique of changing the focal distance of for example, relay optical system, changing the magnitude of the secondary light source formed of a fly eye lens, making it change of the magnitude of this secondary light source interlocked with, and changing the magnitude of opening of an aperture diaphragm there is proposed. In this case, the numerical aperture of the flux of light which carries out incidence to a fly eye lens changes with change of the focal distance of relay optical system. Moreover, when performing deformation lighting which restricts the configuration of the secondary light source the shape of zona orbicularis, and in the shape of 4 poles, it was not easy to manufacture the variable aperture for making adjustable continuously the secondary light source of the shape of the shape of these zona orbicularis or 4 poles. Moreover, in order not to generate lighting unevenness, the illumination light needed to be irradiated to all the plane of incidence of each lens element of a fly eye lens which has lapped with the opening part of a variable aperture.
[0006]

[Problem(s) to be Solved by the Invention] The light source of a large number discretely formed in the backside [a fly eye lens] focal plane constitutes the secondary light source from above conventional techniques. In this case, if the numerical aperture of the incoming beams to a fly eye lens becomes comparatively small with change of the focal distance of relay optical system, the magnitude of each light source formed will become small, and the ratio of the area which much light sources occupy to an overall area of the secondary light source will become small. Consequently, even if it changes the magnitude of opening of an aperture diaphragm continuously, the magnitude of the secondary light source restricted by the aperture diaphragm will change nonsequetially (gradually).
[0007] On the other hand, if the numerical aperture of the incoming beams to a fly eye lens becomes comparatively large with change of the focal distance of relay optical system, quantity of light loss will occur in each lens element which constitutes a fly eye lens. Moreover, since manufacture of a variable aperture was difficult, it was not realistic to have changed the configuration of the secondary light source continuously with the conventional technique at the time of deformation lighting. Moreover, with the conventional technique, since it is necessary to illuminate the plane of incidence of a fly eye lens sufficiently more greatly in order not to generate lighting unevenness, there is un-arranging [that quantity of light loss is large]. As mentioned above, with the conventional technique, there is un-arranging [that lighting conditions cannot be changed almost continuously], without carrying out quantity of light loss substantially in the fly eye lens as an optical integrator of a wavefront-splitting mold.
[0008] This invention aims at offering the aligner equipped with the illumination-light study equipment and this illumination-light study equipment to which lighting conditions can be changed almost continuously, without being made in view of the above-mentioned technical problem, and carrying out quantity of light loss substantially in the optical integrator of a wavefront-splitting mold. Moreover, this invention aims at offering the manufacture approach of a micro device that a good micro device can be manufactured under good lighting conditions, using the aligner to which lighting conditions can be changed almost continuously.
[0009]
[Means for Solving the Problem] In order to solve said technical problem, in the 1st invention of this invention In the illumination-light study equipment for illuminating an irradiated plane based on the flux of light from the light source The optical integrator of the wavefront-splitting mold which has the microlens element of a large number which have been arranged in the optical path between said light sources and said irradiated planes, and were arranged two-dimensional, It has the light guide optical system arranged in the optical path between said optical integrators and said irradiated planes, and the illumination-light study equipment characterized by forming the secondary light source of the predetermined configuration as a virtual image in the plane-of-incidence location of said optical integrator is offered.
[0010] According to the desirable mode of the 1st invention, whenever [maximum angle-of-incidence / of the incoming beams to said optical integrator] is set up so that the injection side of said optical integrator may be illuminated by 60% or more of ratio.
[0011] Moreover, according to the desirable mode of the 1st invention, it is arranged in the optical path between said light sources and said optical integrators. The flux of light sensing element for changing into the flux of light which has the flux of light or the optical predetermined intensity distribution of said light source which has a predetermined cross-section configuration for the parallel flux of light mostly, It has been arranged in the optical path between said flux of light sensing elements and said optical integrators, and has further the relay optical system for forming said secondary light source as a virtual image in said plane-of-incidence location of said optical integrator based on the flux of light through said flux of light sensing element.
[0012] Said flux of light sensing element is arranged near the before [said relay optical system] side focal plane. In this case, the injection side location of said optical integrator It is arranged near the backside [said relay optical system] focal plane. The injection side of said optical integrator It is optically arranged mostly with said flux of light sensing element through said relay optical system conjugate, and, as for the plane of incidence of said optical integrator, it is desirable to be optically arranged mostly with said irradiated plane through said light guide optical system and said optical integrator conjugate. Moreover, in order to change the magnitude of said whole secondary light source formed in the plane-of-incidence location of said optical integrator as a virtual image in this case, as for said relay optical system, it is desirable to be constituted as variable power optical system which has an adjustable focal distance.
[0013] Furthermore, when set magnitude for a light emitting part of said flux of light sensing element to d, the focal distance of said relay optical system is set to fr, the focal distance of each microlens element which

constitutes said optical integrator is set to fe and magnitude of each microlens element is set to de so that the injection side of said optical integrator may be illuminated by 80% or more of ratio, it is desirable to satisfy the conditions of d> 0.8 (fr/fe) and de. In this case, it is desirable to have the light emitting part part modification means for changing magnitude d for a light emitting part of said flux of light sensing element. Moreover, it is desirable to have an afocal zoom lens for adjusting the magnitude of the cross section of the flux of light which said light emitting part part modification means is arranged at the light source side of said flux of light sensing element, and carries out incidence to said flux of light sensing element in this case.
[0014] Or according to the desirable mode of the 1st invention, it is arranged in the optical path between said light sources and said optical integrators. The flux of light sensing element for changing into the flux of light which has the flux of light or the optical predetermined intensity distribution of said light source which has a predetermined cross-section configuration for the parallel flux of light mostly, The 1st relay optical system for leading the flux of light which has been arranged in the optical path between said flux of light sensing elements and said optical integrators, and minded said flux of light sensing element to a predetermined side, The flux of light emission component for making the flux of light which it was positioned in said predetermined side and carried out incidence through said 1st relay optical system emit, It is arranged in the optical path between said flux of light emission components and said optical integrators, and has the 2nd relay optical system which makes conjugate optically said flux of light emission component and injection side location of said optical integrator mostly.
[0015] In this case, said flux of light sensing element is arranged near the before [said 1st relay optical system] side focal plane, and, as for said flux of light emission component, it is desirable to be arranged near the backside [said 1st relay optical system] focal plane. Moreover, in order to change the magnitude of said whole secondary light source formed in the plane-of-incidence location of said optical integrator as a virtual image in this case, as for said 1st relay optical system, it is desirable to be constituted as variable power optical system which has an adjustable focal distance.
[0016] Furthermore, so that the injection side of said optical integrator may be illuminated by 80% or more of ratio Set whenever [maximum angle-of-emergence / of the injection flux of light from said flux of light emission component] to thetab, and the image formation scale factor of said 2nd relay optical system is set to beta. When the focal distance of each microlens element which constitutes said optical integrator is set to fe and magnitude of each microlens element is set to de, it is desirable to satisfy the conditions of thetab>0.8 and sin-1 (|beta| and de/fe). In this case, in order to suppress fluctuation of thetab whenever [maximum angle-of-emergence / of the injection flux of light from said flux of light emission component accompanying change of the focal distance of said 1st relay optical system], it is [whenever / maximum incident angle / of the incoming beams to said flux of light emission component] more desirable [thetaa / whenever / said maximum angle-of-emergence] than thetab to be set up small substantially. As for these flux of light sensing elements and a flux of light emission component, it is desirable to have a diffracted-light study component, a minute prism array, or a micro fly eye lens. Moreover, as for the plane of incidence of said optical integrator, it is optically [as an irradiated plane] desirable that it is conjugation mostly.
[0017] In the 2nd invention of this invention, the aligner characterized by having the illumination-light study equipment of the 1st invention and the projection optics for carrying out projection exposure of the pattern of the mask set as said irradiated plane to up to a photosensitive substrate is offered.
[0018] In the 3rd invention of this invention, the manufacture approach of the micro device characterized by including the exposure process which exposes the pattern of said mask on said photosensitive substrate with the aligner of the 2nd invention, and the development process which develops said photosensitive substrate exposed by said exposure process is offered.
[0019]
[Embodiment of the Invention] With the typical operation gestalt of this invention, the parallel flux of light is mostly changed into the flux of light of a circle configuration through the diffracted-light study component as a flux of light sensing element from the light source like an excimer laser. The flux of light of the circle configuration formed through the diffracted-light study component forms the secondary light source of the circle configuration as a virtual image in a plane-of-incidence location of the optical integrator of a wavefront-splitting mold like a fly eye lens through relay optical system and the optical integrator itself. The flux of light from the secondary light source of a circle configuration carries out circular lighting of an irradiated plane like a mask through light guide optical system.
[0020] As mentioned above, unlike the conventional technique in which the light source of a large number

discretely formed in the backside [a fly eye lens] focal plane constitutes the secondary light source from this invention, the secondary light source as the surface light source of a predetermined configuration is formed in the plane of incidence of a fly eye lens as a virtual image. Therefore, lighting conditions can be changed almost continuously, without carrying out quantity of light loss substantially in a fly eye lens, if the injection side of a fly eye lens is illuminated by the predetermined ratio.
[0021] Therefore, with the aligner incorporating the illumination-light study equipment of this invention, since lighting conditions can be changed almost continuously, without carrying out quantity of light loss substantially in a fly eye lens, a good micro device can be manufactured under good lighting conditions at a high throughput.
[0022] The operation gestalt of this invention is explained based on an accompanying drawing. Drawing 1 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the 1st operation gestalt of this invention. Moreover, drawing 2 is the enlarged drawing showing roughly the important section configuration from the diffracted-light study component in the aligner of drawing 1 to a lighting field diaphragm (mask blind). In drawing 1 , the X-axis is set [the Z-axis] up in the direction perpendicular to the space of drawing 1 for the Y-axis in a wafer side in the direction parallel to the space of drawing 1 in a wafer side along the direction of a normal of the wafer W which is a photosensitive substrate, respectively.
[0023] The aligner of drawing 1 is equipped with the excimer laser which supplies wavelength (248nm (KrF) or 193nm (ArF)) of light as the light source 1 for supplying exposure light (illumination light). It has the rectangle-like cross section which was injected along with the Z direction from the light source 1 and where the parallel flux of light was mostly prolonged long and slender along the direction of X, and incidence is carried out to the beam expander 2 which consists of lens 2a of a pair, and 2b. Each lens 2a and 2b have negative refractive power and forward refractive power in the space of drawing 1 (inside of YZ flat surface), respectively. Therefore, the flux of light which carried out incidence to the beam expander 2 is expanded in the space of drawing 1 , and is orthopedically operated by the flux of light which has the cross section of the shape of a predetermined rectangle.
[0024] Mostly, after [through the beam expander 2 as plastic surgery optical system] the parallel flux of light is deflected in the direction of Y by the bending mirror 3, incidence of it is carried out to the diffracted-light study component (DOE) 4. The diffracted-light study component 4 is constituted by forming the level difference which has the pitch of wavelength extent of exposure light (illumination light) in a glass substrate, and has the operation which diffracts an incident beam at a desired include angle. Specifically, the diffracted-light study component 4 changes rectangle-like incoming beams into the flux of light of the circle configuration centering on an optical axis AX.
[0025] Incidence of the flux of light through the diffracted-light study component 4 as a flux of light sensing element is carried out to the fly eye lens 6 as an optical integrator of a wavefront-splitting mold through the relay optical system 5. The fly eye lens 6 is constituted by arranging in all directions and densely the lens element of a large number which have forward refractive power. And each lens element is constituted so that an after that side focal plane and a injection side may be mostly in agreement and the before side focal plane and plane of incidence may be mostly in agreement.
[0026] Moreover, as shown in drawing 2 , it is arranged so that a before [the relay optical system 5] side focal plane and the diffraction side of the diffracted-light study component 4 may be in agreement and a backside [the relay optical system 5] focal plane and the injection side location of the fly eye lens 6 may be in agreement. Therefore, the far field pattern of the circle configuration by the relay optical system 5 is formed in the injection side location of the fly eye lens 6. In addition, in this specification, the injection side and the injection side location are distinguished clearly. In drawing 2 , the diffracted-light study component 4 as a flux of light sensing element and the injection side of the fly eye lens 6 are conjugation, and image formation of the diffracted-light study component 4 is carried out to the injection side of the fly eye lens 6. On the other hand, according to the refraction operation by the plane of incidence of the fly eye lens 6, although the location of the injection side of the fly eye lens 6 is in a backside [the relay optical system 5] focus, the flux of light which carried out incidence in parallel to the relay optical system 5 will condense in the center of the fly eye lens 6, as shown in drawing 3 . That is, in the example of drawing 2 , the injection side 6a of the fly eye lens 6 itself is not in a backside [the relay optical system 5] focus, but the injection side location of the fly eye lens 6 is located in a backside [the relay optical system 5] focal location. Here, when the refractive index n of each lens element of the fly eye lens 6 is taken into consideration, a far field pattern will be formed in the location of t/n from the plane of incidence of the fly eye lens 6, using thickness (die length in alignment with an optical

axis) of each lens element as t. Moreover, since the diffracted-light study component 4 as a flux of light sensing element is in a before [the relay optical system 5] side focal location, the flux of light which illuminates the fly eye lens 6 is the tele cent rucksack flux of light fundamentally.
[0027] The flux of light which passed the fly eye lens 6 illuminates the mask blind 8 as a lighting field diaphragm in superposition through a condenser lens 7. Here, as shown in drawing 2 , it is arranged so that a before [a condenser lens 7] side focal plane and the plane-of-incidence location of the fly eye lens 6 may be in agreement and a backside [a condenser lens 7] focal plane and the mask blind 8 may be in agreement. And the diffraction side of the diffracted-light study component 4 and the injection side of the fly eye lens 6 are optically arranged through the relay optical system 5 conjugate. Moreover, the plane of incidence and the mask blind 8 of the fly eye lens 6 are optically arranged through the condenser lens 7 conjugate. In addition, in this specification, plane of incidence and a plane-of-incidence location are distinguished clearly. If the parallel flux of light shown in drawing 2 with a broken line is reverse-pursued from the mask blind 8 side, this parallel flux of light will condense not in the plane of incidence of the fly eye lens 6 but in the center of the fly eye lens 6 according to the refraction operation in respect of injection of the fly eye lens 6. That is, in the example of drawing 2 , the plane-of-incidence 6b of the fly eye lens 6 itself is not in a before [a condenser lens 7] side focus, but the plane-of-incidence location of the fly eye lens 6 is located in a before [a condenser lens 7] side focal location.
[0028] Therefore, as continuous-line section 6a shows drawing 2 , optical predetermined intensity distribution are formed in the injection side of the fly eye lens 6. And as a result, as broken-line section 6b shows drawing 2 , it seems that the secondary light source of a circle configuration is formed in the plane-of-incidence location of the fly eye lens 6 from a condenser lens 7. A paraphrase forms secondary light source 6b of the circle configuration as a virtual image in the plane-of-incidence location of the fly eye lens 6. Hereafter, this point is explained with reference to drawing 3 .
[0029] One point of the light source shall be formed in the central point B of the injection side of the lens element e1 by the side of drawing Nakagami in drawing 3 . In this case, when a beam of light is pursued, it seems that light is injected from the central point A of the plane of incidence of the lens element e1 from a condenser lens 7. On the other hand, one point of the light source shall be formed in point B' from which it separated from the central point of the injection side of the lens element e2 by the side of drawing Nakashita. this -- a case -- a beam of light -- pursuing -- if -- the -- a lens -- an element -- e -- two -- plane of incidence -- setting -- a point -- B -- ' -- countering -- a point -- A -- ' -- from -- light -- injecting -- having -- **** -- as -- from a condenser lens 7 -- being visible .
[0030] Furthermore, although the plane of incidence of the fly eye lens 6 is optically arranged with the mask blind 8 conjugate as mentioned above, considering three points a, b, and c of corresponding, it turns out that it is injected at the include angle with the light same from Point A and A' which carries out incidence at Point B and B'. That is, corresponding to the optical intensity distribution formed in the injection side of the fly eye lens 6, the secondary light source of the circle configuration as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6. For this reason, what is necessary will be to make the plane-of-incidence location of the fly eye lens 6 into the forming face of the secondary light source, and just to illuminate the mask blind 8 through a condenser lens 7. In addition, he can understand that the real image of Point B is formed in the center of the lens element of the fly eye lens 6 from drawing 3 . Therefore, when laser resistance is taken into consideration, it is desirable to divide the fly eye lens 6 and to locate the point condensing [laser] between the divided lens elements.
[0031] The flux of light through opening (light transmission section) of the shape of a rectangle of the mask blind 8 illuminates in superposition the mask M with which the predetermined pattern was formed, after receiving a condensing operation of the image formation optical system 9. In this way, the image formation optical system 9 will form the image of opening of the shape of a rectangle of the mask blind 8 on Mask M. The flux of light which penetrated the pattern of Mask M forms the image of a mask pattern through projection optics PL on the wafer W which is a photosensitive substrate. In this way, the pattern of Mask M is serially exposed by each exposure field of Wafer W by performing one-shot exposure or scanning exposure, carrying out drive control of the wafer W two-dimensional into the flat surface (XY flat surface) which intersects perpendicularly with the optical axis AX of projection optics PL. Here, the plane of incidence of the fly eye lens 6 is maintaining conjugate mostly optically with the mask as an irradiated plane, and the mask conjugation side (the mask blind 8, Wafer W), and lighting nonuniformity here is not generated.
[0032] In addition, in one-shot exposure, a mask pattern is exposed in package to each exposure field of a

wafer according to the so-called step-and-repeat method. In this case, the configuration of the lighting field on Mask M has the shape of a rectangle near a square, and turns into the shape of a rectangle also with the cross-section configuration of each lens element of the fly eye lens 6 near a square. On the other hand, in scanning exposure, scanning exposure of the mask pattern is carried out to each exposure field of a wafer according to so-called step - and - scanning method, making a mask and a wafer displaced relatively to projection optics. In this case, the ratio of a shorter side and a long side has the shape of a rectangle of 1:3, and the configuration of the lighting field on Mask M turns into the shape of a rectangle [**** / the cross-section configuration of each lens element of the fly eye lens 6 / this].

[0033] Here, when it can be burned in a detailed pattern that it is about 1% or less, it is important for whenever [of the circular configuration (light source configuration) of the illumination-light bundle which carries out incidence to an irradiated plane (a mask side and wafer side) / flat]. Moreover, it is desirable to avoid with the incidence location on an irradiated plane, as the configurations of an illumination-light bundle can also differ. Then, in drawing 3 , it is desirable for the between from the point B on the injection side of the upper limit lens element e1 which constitutes the fly eye lens 6 to point B' on the injection side of the lower limit lens element e2 to cover the whole, and to illuminate it completely (namely, extensively).

[0034] What is necessary is on the other hand, to change the focal distance of the relay optical system 5, and just to change the magnitude of the secondary light source (virtual image) of the circle configuration formed in the plane of incidence of the fly eye lens 6, in order to change lighting conditions. However, if NA (numerical aperture) of the flux of light which carries out incidence to the fly eye lens 6 with change of the focal distance of the relay optical system 5 in this case becomes small, even if the injection side of the fly eye lens 6 is no longer illuminated extensively and it changes the magnitude of the secondary light source continuously, change (as a result, change of lighting conditions) of a light source configuration will serve as discontinuity.

[0035] As mentioned above, in order to change a light source configuration continuously, it is desirable to illuminate the injection side of the fly eye lens 6 extensively. However, in fact, the injection side of the fly eye lens 6 is 60% or more of ratio, if preferably illuminated by 80% or more of ratio, a light source configuration can be changed almost continuously, as a result lighting conditions can be changed almost continuously. In order to illuminate the injection side of the fly eye lens 6 by 80% or more of ratio, it is necessary to satisfy the following conditional expression (1) and (2).

[0036]

d1> 0.8 (fr/fe), de1 (1)

d2> 0.8 (fr/fe), de2 (2)

Here, d1 is the magnitude of the direction of X for a light emitting part of the diffracted-light study component 4, and d2 is the magnitude of the Z direction for a light emitting part of the diffracted-light study component 4. Moreover, fr is the focal distance of the relay optical system 5, and fe is the focal distance of each lens element of the fly eye lens 6. Furthermore, de1 is the magnitude of the direction of X of each lens element, and de2 is the magnitude of the Z direction of each lens element.

[0037] When conditional expression (1) and (2) are referred to, it turns out that it is desirable that the cross-section configuration of the incoming beams to the diffracted-light study component 4 and the cross-section configuration of each lens element are similarities. In addition, when the lighting field of a mask benefits scanning exposure long and slender, for example (i.e., when the cross-section configuration of a lens element becomes long and slender), the conditional expression which met the longitudinal direction conditional expression (1) and among (2) becomes important.

[0038] Here, as mentioned above, in order to change the magnitude of the secondary light source continuously, it is necessary to change the focal distance of the relay optical system 5 continuously. When the focal distance fr of the relay optical system 5 changes, it becomes impossible to satisfy conditional expression (1) and (2), and it becomes impossible however, to change a light source configuration almost continuously. While changing the focal distance fr of the relay optical system 5 so that the afocal zoom lens 11 may be attached to the light source side of the diffracted-light study component 4 as shown in the modification of drawing 4 in this case, and conditional expression (1) and (2) may always be satisfied, it is desirable to change the scale factor of the afocal zoom lens 11, and to change the magnitude for a light emitting part of the diffracted-light study component 4 (d1xd2).

[0039] Drawing 5 - drawing 7 are drawings showing the secondary light source of the circle configuration as a virtual image formed in the plane of incidence of a fly eye lens. Here, drawing 5 shows the secondary light source of the smallest circle configuration in the so-called small mho condition. Moreover, drawing 7 shows the

secondary light source of the largest circle configuration in the so-called large mho condition. Furthermore, drawing 6 shows the secondary light source of the circle configuration which has the in-between magnitude in a so-called inside sigma condition.
[0040] As mentioned above, unlike the conventional technique in which the light source of a large number discretely formed in the backside [a fly eye lens] focal plane constitutes the secondary light source from a 1st operation gestalt, the secondary light source as the surface light source of a circle configuration is formed in the plane of incidence of the fly eye lens 6 as a virtual image. Therefore, if the injection side of the fly eye lens 6 is illuminated by the predetermined ratio, for example, 80% or more of ratio, lighting conditions can be changed almost continuously, without carrying out quantity of light loss substantially in the fly eye lens 6.
[0041] If the sigma value in circular lighting is specifically reduced, without carrying out quantity of light loss substantially in the fly eye lens 6 by changing the focal distance fr of the relay optical system 5 so that it may always be satisfied with the 1st operation gestalt of conditional expression (1) and (2), lighting conditions can be changed almost continuously. Moreover, the aperture diaphragm for restricting the secondary light source with the 1st operation gestalt unlike the conventional technique is unnecessary.
[0042] In addition, with the 1st operation gestalt, the minute prism array which replaces with the diffracted-light study component 4, for example, is indicated by drawing 23 thru/or drawing 28 of the European Patent public presentation No. 1014196 official report, the micro fly eye lens indicated by drawing 2 of this official report can also be used. Moreover, with the 1st operation gestalt, although this invention is explained taking the case of the case of circular lighting, deformation lighting like zona-orbicularis lighting or 4 pole lighting can also be performed by replacing with the diffracted-light study component 4, and forming the secondary zona-orbicularis-like light source and the secondary 4 pole-like light source using the diffracted-light study component for zona-orbicularis lighting, or the diffracted-light study component for 4 pole lighting. These points are the same also in other below-mentioned operation gestalten.
[0043] Drawing 8 is drawing showing roughly the important section configuration of the aligner equipped with the illumination-light study equipment concerning the 2nd operation gestalt of this invention. In drawing 8 , it bends from the light source 1 in drawing 1 , and illustration of the part to a mirror 3 and the part from the condenser lens 7 in drawing 1 to Wafer W is omitted. That is, the 2nd operation gestalt has the gestalt by which the diffracted-light study component 4 and the relay optical system 5 in the 1st operation gestalt were permuted by the 1st diffracted-light study component 20 - the 2nd relay optical system 24. Hereafter, the 2nd operation gestalt is explained paying attention to difference with the 1st operation gestalt.
[0044] With the 2nd operation gestalt, the parallel flux of light carries out incidence to the 1st diffracted-light study component 20 mostly from the light source 1. The 1st diffracted-light study component 20 has the same function as the diffracted-light study component 4 in the 1st operation gestalt. Therefore, the flux of light injected by predetermined angular distribution from the 1st diffracted-light study component 20 forms the optical intensity distribution of a circle configuration through the relay optical system 5 in the 1st operation gestalt, and the 1st relay optical system 21 which has the same function on the 2nd diffracted-light study component 22 positioned in the after that side focal plane. After the flux of light through the 2nd diffracted-light study component 22 as a flux of light emission component is restricted by the aperture diaphragm 23, incidence of it is carried out to the fly eye lens 6 through the 2nd relay optical system 24 which has a fixed focal distance.
[0045] Here, the 2nd diffracted-light study component 22 and the injection side location of the fly eye lens 6 are optically arranged through the 2nd relay optical system 24 conjugate. If it puts in another way, it is constituted so that the amount of [of the 2nd diffracted-light study component 22] light emitting part may carry out image formation to the injection side location of the fly eye lens 6 through the 2nd relay optical system 24. Therefore, also in the 2nd operation gestalt, the secondary light source of the circle configuration as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6 like the 1st operation gestalt. In addition, in the 2nd operation gestalt, since the 1st diffracted-light study component 20 as a flux of light sensing element is in a before [the 1st relay optical system 21] side focal location, telecentric lighting of the 2nd diffracted-light study component 22 as a flux of light emission component is carried out. And since the 2nd relay optical system 24 is a tele cent rucksack (this operation gestalt both-sides tele cent rucksack) at the fly eye lens 6 side, telecentric lighting of the fly eye lens 6 is carried out by the flux of light from the 2nd diffracted-light study component 22.
[0046] In addition, in the 2nd operation gestalt, in order to constitute so that the injection side of the fly eye lens 6 may be illuminated densely extensively, thetac2 must satisfy the following conditional expression (3) and

(4), respectively whenever [maximum incident angle / which met thetac1 and a Z direction whenever / maximum incident angle / which met in the direction of X of the incoming beams to the fly eye lens 6].
sin(thetac1) >de1/(2, fe) (3)
sin(thetac2) >de2/(2, fe) (4)
Here, as mentioned above, de1 is the magnitude of the direction of X of each lens element, and de2 is the magnitude of the Z direction of each lens element. Moreover, fe is the focal distance of each lens element of the fly eye lens 6.
[0047] In fact, as mentioned above, the injection side of the fly eye lens 6 is 60% or more of ratio, if preferably illuminated by 80% or more of ratio, a light source configuration can be changed almost continuously, as a result lighting conditions can be changed almost continuously. In order to illuminate the injection side of the fly eye lens 6 by 80% or more of ratio in the 2nd operation gestalt, thetab2 needs to satisfy the following conditional expression (5) and (6) whenever [maximum angle-of-emergence / which met thetab1 and a Z direction whenever / maximum angle-of-emergence / which met in the direction of X of the injection flux of light from the 2nd diffracted-light study component 22].
[0048]
thetab1>0.8 and sin-1 (|beta|, de1/fe) (5)
thetab2>0.8 and sin-1 (|beta|, de2/fe) (6)
Here, beta is the image formation scale factor of the 2nd relay optical system 24.
[0049] If in the case of the 2nd operation gestalt the focal distance of the 1st relay optical system 21 is changed in order to change lighting conditions, thetaa will also change whenever [maximum incident angle / of the incoming beams to the 2nd diffracted-light study component 22]. Consequently, whenever [to the 2nd diffracted-light study component 22 / maximum incident angle], with change of thetaa, thetab also changes whenever [from the 2nd diffracted-light study component 22 / maximum angle-of-emergence], and there is a case where it becomes impossible to always satisfy conditional expression (5) and (6). In this case, it is desirable to suppress fluctuation of thetab small whenever [maximum angle-of-emergence] suppressing fluctuation of thetaa small whenever [accompanying change of the focal distance of the 1st relay optical system 21 / maximum incident angle], i.e., by holding down the value of thetaa itself small whenever [maximum incident angle].
[0050] That is, in order to change the focal distance of the 1st relay optical system 21 and to change lighting conditions almost continuously, being always satisfied with the 2nd operation gestalt of conditional expression (5) and (6), it is desirable to satisfy the following conditional expression (7).
thetaa<(1/2) -thetab (7)
In addition, in order to change lighting conditions still more certain almost continuously, it is desirable to set the multiplier of thetab as one fifth in the right-hand side of conditional expression (7).
[0051] Moreover, the configuration which adjusts the path of the flux of light which attaches an afocal zoom lens as shown in the light source side of the 1st diffracted-light study component 20 at drawing 4 with the 2nd operation gestalt, and carries out incidence to the 1st diffracted-light study component 20 using this afocal zoom lens is also possible. By this configuration, it cannot be concerned with change of the focal distance of the 1st relay optical system 21, thetaa can be kept constant whenever [to the 2nd diffracted-light study component 22 / maximum incident angle], as a result thetab can be kept constant whenever [from the 2nd diffracted-light study component 22 / maximum angle-of-emergence], and conditional expression (5) and (6) can always be satisfied.
[0052] Furthermore, although the absolute value of the image formation scale factor beta of the 2nd relay optical system 24 is shown more greatly than 1 by drawing 8 , the optimal image formation scale factor beta of the 2nd relay optical system 24 is determined by not the conditions that need this for the 2nd operation gestalt but the emission engine performance of the 2nd diffracted-light study component 22. Therefore, the absolute value of the image formation scale factor beta of the 2nd relay optical system 24 can be set to |beta|=1 or |beta|<1.
[0053] Furthermore, with the 2nd operation gestalt, it can replace with the 2nd diffracted-light study component 22, and a minute prism array, a fly eye lens, etc. can also be used. As shown in drawing 9 , it replaces with the 2nd diffracted-light study component 22, and, in the case of the modification using the fly eye lens 25, thetab is [whenever / maximum angle-of-emergence / from the plane of incidence of the fly eye lens 25 when the injection side of the fly eye lens 25 is illuminated by thetaa whenever / maximum incident angle] dependent only on the shape parameter of the fly eye lens 25.

[0054] That is, in the modification of the 2nd operation gestalt shown in drawing 9 , whenever [maximum angle-of-emergence], since thetab is not changed whenever [maximum incident angle] depending on thetaa, always satisfying conditional expression (5) and (6), the focal distance of the 1st relay optical system 21 can be changed, and lighting conditions can be changed almost continuously. In addition, the injection side of the fly eye lens 25 does not necessarily need to be extensively illuminated in this case.
[0055] Moreover, with the 2nd operation gestalt, zona-orbicularis lighting, 4 pole lighting, etc. can also be performed by arranging the so-called axicon in the optical path between the 1st relay optical system 21 and the 2nd diffracted-light study component 22. In this case, the magnitude of the whole secondary light source can be changed by constituting an axicon from cone prism (cone convex prism and cone concave prism) of a pair, and changing that spacing, keeping constant the width of face (difference of an outer diameter and a bore) of the secondary zona-orbicularis-like light source. In addition, as an axicon, what is indicated by drawing 43 of the European Patent public presentation No. 1014196 official report, for example can be used.
[0056] Moreover, the magnitude of the whole secondary light source can be changed by constituting an axicon from pyramid prism (forward 4 pyramid convex prism and forward 4 pyramid concave prism) of a pair, and changing the spacing, keeping constant the magnitude of the four light sources which constitute the secondary 4 pole-like light source. In addition, it cannot be overemphasized by changing the focal distance of the 1st relay optical system 21 in this case that the whole secondary light source of the shape of the shape of zona orbicularis and 4 poles can be expanded in similarity, or it can reduce.
[0057] Drawing 10 is drawing showing roughly the important section configuration of the aligner equipped with the illumination-light study equipment concerning the 3rd operation gestalt of this invention. In drawing 10 , it bends from the light source 1 in drawing 1 , and illustration of the part to a mirror 3 and the part from the condenser lens 7 in drawing 1 to Wafer W is omitted. That is, with the 3rd operation gestalt, the afocal zoom lens 30 - the 2nd relay optical system 32 are attached into the optical path between the bending mirrors 3 and the diffracted-light study components 4 in the 1st operation gestalt. Hereafter, the 3rd operation gestalt is explained paying attention to difference with the 1st operation gestalt.
[0058] With the 3rd operation gestalt, mostly, the parallel flux of light carries out incidence to the 2nd diffracted-light study component 31, after being orthopedically operated by the cross-section configuration of desired magnitude through the afocal zoom lens 30 from the light source 1. Here, when the afocal zoom lens 30 contains a cylindrical lens, the aspect ratio of the rectangle-like cross section of the flux of light which carries out incidence to the 2nd diffracted-light study component 31 can be changed. The flux of light emitted to the circle configuration (the shape of a ring, 4 punctiforms) through the 2nd diffracted-light study component 31 forms the optical intensity distribution of a circle configuration (the shape of a ring, 4 punctiforms) in the pupil surface of the 2nd relay optical system 32.
[0059] In this way, the diffracted-light study component 4 is illuminated by the angular distribution of a circle configuration (the shape of a ring, 4 punctiforms). As mentioned above, the diffracted-light study component 4 has the operation which emits incoming beams to a circle configuration. Therefore, after the flux of light through the diffracted-light study component 4 minds the relay optical system 5, the optical intensity distribution based on the convolution of a circle (a ring or four points) and a circle, i.e., the optical intensity distribution of a circle configuration (the shape of the shape of zona orbicularis and 4 poles), are formed. A paraphrase forms the secondary light source of the circle configuration (the shape of the shape of zona orbicularis, and 4 poles) as a virtual image in the plane-of-incidence location of the fly eye lens 6.
[0060] With the 3rd operation gestalt, the magnitude of the whole secondary light source of a circle configuration can be changed changing the image formation scale factor of the 2nd relay optical system 32, or by changing the focal distance of the relay optical system 5. Moreover, the magnitude of the whole secondary light source can be changed by changing the image formation scale factor of the 2nd relay optical system 32, keeping constant the width of face (or magnitude of the four light sources which constitute the secondary 4 pole-like light source) of the secondary zona-orbicularis-like light source. Furthermore, by changing the focal distance of the relay optical system 5, the secondary whole zona-orbicularis-like (shape of or 4 poles) light source can be expanded in similarity, or it can reduce.
[0061] However, if the image formation scale factor of the 2nd relay optical system 32 is changed or the focal distance of the relay optical system 5 is changed, the numerical aperture (it corresponds to include-angle thetac of drawing 10) of the flux of light which carries out incidence to the fly eye lens 6 will change. The injection side of the fly eye lens 6 is no longer illuminated by sufficient ratio, and it becomes impossible consequently, to change lighting conditions almost continuously. So, with the 3rd operation gestalt, by adjusting

the diameter of the flux of light which the scale factor of the afocal zoom lens 30 is changed, and carries out incidence to the 2nd diffracted-light study component 31, and finally setting thetac as a desired value whenever [maximum incident angle / of the incoming beams to the fly eye lens 6], the injection side of the fly eye lens 6 can be illuminated by always sufficient ratio, and lighting conditions can be changed almost continuously.
[0062] In addition, in the 3rd operation gestalt, the minute prism array which replaces with the 2nd diffracted-light study component 31, for example, is indicated by drawing 23 thru/or drawing 28 of the European Patent public presentation No. 1014196 official report, the micro fly eye lens indicated by drawing 2 of this official report can also be used. When replacing with the 2nd diffracted-light study component 31 and using a micro fly eye lens, in order to use the quantity of light effectively, it is desirable to set up the cross-section configuration of each lens element in the shape of a forward hexagon, to carry out the closest packing of the forward hexagon-like lens element of these large number, and to constitute it. Moreover, the 2nd diffracted-light study component 31 may be the aggregate of a very small DOE lens, a phase is arranged appropriately and diffracted-light distribution may turn into desired distribution.
[0063] Hereafter, a still more concrete operation gestalt is explained. Drawing 11 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the 4th operation gestalt of this invention. Although the 4th operation gestalt has a configuration similar to the 2nd operation gestalt, the point that the micro fly eye lens (micro-lens array: micro fly eye) 40 and the afocal zoom lens 41 are attached into the optical path between the bending mirror 3 and the 1st diffracted-light study component 20 is fundamentally different from the 2nd operation gestalt. Hereafter, the 4th operation gestalt is explained paying attention to difference with the 2nd operation gestalt. In addition, in drawing 11 , it is set up so that illumination-light study equipment may perform zona-orbicularis lighting.
[0064] with the 4th operation gestalt, it was injected from the light source 1 -- the parallel flux of light carries out incidence to the micro fly eye lens 40 for zona-orbicularis lighting through the beam expander 2 and the bending mirror 3 mostly. The micro fly eye lens 40 is an optical element which consists of a microlens which has the forward refractive power of the shape of a forward hexagon of a large number arranged in all directions and densely. Generally, a micro fly eye lens is constituted by performing etching processing to for example, an parallel flat-surface glass plate, and forming a microlens group. In addition, there are also very few twists and the number of the microlenses which constitute the micro fly eye lens 40 for clear-izing of a drawing is actually expressed with drawing 11 .
[0065] The flux of light which carried out incidence to the micro fly eye lens 40 is divided by many microlenses two-dimensional, and the one light source is formed in a backside [each microlens] focal plane, respectively. The flux of light from the light source of a large number formed in the backside [the micro fly eye lens 40] focal plane turns into the emission flux of light which has a forward hexagon-like cross section, respectively, and carries out incidence to the afocal zoom lens 41. Thus, the micro fly eye lens 40 constitutes the include-angle flux of light means forming for changing the flux of light from the light source 1 into the flux of light which has two or more include-angle components to an optical axis AX.
[0066] In addition, to the illumination-light way, it is constituted free [insertion and detachment], and the micro fly eye lens 40 for zona-orbicularis lighting is constituted possible [micro fly eye lens 40a for 4 pole lighting, and a switch]. About the configuration and operation of micro fly eye lens 40a for 4 pole lighting, it mentions later. Moreover, maintaining an afocal system (non-focal optical system), the afocal zoom lens 41 is constituted so that a scale factor can be continuously changed in the predetermined range.
[0067] Here, evacuation from the illumination-light way of the switch and each micro fly eye lenses 40 and 40a of the micro fly eye lens 40 for zona-orbicularis lighting and micro fly eye lens 40a for 4 pole lighting is performed by the 1st drive system 52 which operates based on the command from a control system 51. Moreover, scale-factor change of the afocal zoom lens 41 is performed by the 2nd drive system 53 which operates based on the command from a control system 51.
[0068] Incidence of the flux of light through the afocal zoom lens 41 is carried out to 1st diffracted-light study component 20a for zona-orbicularis lighting. The emission flux of light from each light source formed in the backside [the micro fly eye lens 40] focal plane at this time is converged on the diffraction side of 1st diffracted-light study component 20a, with a forward hexagon-like cross section maintained. That is, the afocal zoom lens 41 has connected optically a backside [the micro fly eye lens 40] focal plane, and 1st diffracted-light study component 20a to conjugate. And the numerical aperture of the flux of light which condenses to one on 1st diffracted-light study component 20a changes depending on the scale factor of the afocal zoom lens 41.
[0069] in addition -- the zona orbicularis -- lighting -- ** -- the -- one -- the diffracted light -- study -- a

component -- 20 -- a -- the illumination light -- a way -- receiving -- insertion and detachment -- free -- constituting -- having -- and -- four -- a pole -- lighting -- ** -- the -- one -- the diffracted light -- study -- a component -- 20 -- b -- circular -- lighting -- ** -- the -- one -- the diffracted light -- study -- a component -- 20 -- c -- a switch -- possible -- constituting -- having -- **** . About the configuration and operation of 1st diffracted-light study component 20b for 4 pole lighting, and 1st diffracted-light study component 20c for circular lighting, it mentions later. Here, the switch between 1st diffracted-light study component 20a for zona-orbicularis lighting, 1st diffracted-light study component 20b for 4 pole lighting, and 1st diffracted-light study component 20c for circular lighting is performed by the 3rd drive system 54 which operates based on the command from a control system 51.

[0070] When the parallel flux of light which has a rectangle-like cross section carries out incidence of the 1st diffracted-light study component 20a for zona-orbicularis lighting, it is a flux of light sensing element for forming optical ring-like intensity distribution in the far field (Fraunhofer diffraction field). Incidence of the flux of light through 1st diffracted-light study component 20a is carried out to the 2nd diffracted-light study component 22 through the 1st relay optical system 21 which functions as a zoom lens. Here, 1st diffracted-light study component 20a is arranged near the before [the 1st relay optical system 21] side focal location, and the 2nd diffracted-light study component 22 is arranged near the backside [the 1st relay optical system 21] focal location. If it puts in another way, the 1st relay optical system 21 will arrange substantially 1st diffracted-light study component 20a and the 2nd diffracted-light study component 22 in the relation of the Fourier transform.

[0071] Therefore, as mentioned above, when the parallel flux of light which has the cross section of the shape of a rectangle centering on an optical axis AX carries out incidence to 1st diffracted-light study component 20a, the optical intensity distribution of the shape of a ring centering on an optical axis AX are formed in the backside [the 1st relay optical system 21] focal location 22, i.e., the 2nd diffracted-light study component. However, as mentioned above in fact, while the emission flux of light from each light source formed in the backside [the micro fly eye lens 40] focal plane had maintained the forward hexagon-like cross section, it converges on 1st diffracted-light study component 20a. Although the flux of light which has many include-angle components will carry out incidence to 1st diffracted-light study component 20a if it puts in another way, whenever [incident angle] is specified by the forward hexagon-head cone-like flux of light range.

[0072] Therefore, the flux of light through 1st diffracted-light study component 20a forms the optical intensity distribution based on the convolution of the ring and a forward hexagon centering on an optical axis AX, i.e., the optical intensity distribution of the shape of zona orbicularis centering on an optical axis AX (in a circle), on the 2nd diffracted-light study component 22 through the 1st relay optical system 21. The magnitude (outer diameter) of the optical intensity distribution of the shape of this zona orbicularis changes depending on the focal distance of the 1st relay optical system 21. In addition, change of the focal distance of the 1st relay optical system 21 is performed by the 4th drive system 55 which operates based on the command from a control system 51.

[0073] After the flux of light through the 2nd diffracted-light study component 22 as a flux of light emission component is restricted by the aperture diaphragm 23 prepared by approaching the 2nd diffracted-light study component 22, incidence of it is carried out to the fly eye lens 6 through the 2nd relay optical system 24 which has a fixed focal distance. Here, the 2nd diffracted-light study component 22 and the injection side location of the fly eye lens 6 are optically arranged through the 2nd relay optical system 24 conjugate. If it puts in another way, it is constituted so that the amount of [of the 2nd diffracted-light study component 22] light emitting part may carry out image formation to the injection side location of the fly eye lens 6 through the 2nd relay optical system 24. In this way, the secondary light source of the shape of zona orbicularis as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6.

[0074] In addition, the aperture diaphragm 23 is supported on the turret substrate (rotor plate : drawing 1 un-illustrating) pivotable to the circumference of a predetermined axis parallel to an optical axis AX. Two or more zona-orbicularis aperture diaphragms which have opening (light transmission section) of the shape of zona orbicularis from which a configuration (zona-orbicularis ratio) and magnitude (outer diameter) differ, two or more 4 pole aperture diaphragms which have opening of the shape of 4 poles from which a configuration (zona-orbicularis ratio) and magnitude (outer diameter) differ, and two or more circular aperture diaphragms which have opening of the circle configuration from which magnitude (outer diameter) differs are prepared in the turret substrate along with the circumferencial direction. Moreover, the turret substrate is constituted pivotable through the central point at the circumference of an axis parallel to an optical axis AX. Therefore, one aperture diaphragm chosen from many aperture diaphragms can be positioned all over an illumination-light way by

rotating a turret substrate. In addition, rotation of a turret substrate is performed by the 5th drive system 56 which operates based on the command from a control system 51.
[0075] In drawing 1 , since optical zona-orbicularis-like intensity distribution are formed on the 2nd diffracted-light study component 22, one zona-orbicularis aperture diaphragm chosen from two or more zona-orbicularis aperture diaphragms as an aperture diaphragm 23 is used. However, without being limited to the aperture diaphragm of a turret method, the aperture diaphragm of a slide method may be adopted, for example, and the possible aperture diaphragm of changing light transmission area size and a configuration suitably may be attached fixed in an illumination-light way. Furthermore, it can replace with two or more circular aperture diaphragms, and the tris diaphragm to which the diameter of circular opening can be changed continuously can also be prepared.
[0076] The flux of light which passed the fly eye lens 6 illuminates the mask blind 8 as a lighting field diaphragm in superposition through a condenser lens 7. The flux of light through opening (light transmission section) of the shape of a rectangle of the mask blind 8 illuminates Mask M in superposition, after receiving a condensing operation of the image formation optical system 9. The flux of light which penetrated the pattern of Mask M forms the image of a mask pattern on Wafer W through projection optics PL. The adjustable aperture diaphragm for specifying the numerical aperture of projection optics PL is prepared in the entrance pupil side of projection optics PL, and the drive of this adjustable aperture diaphragm is performed by the 6th drive system 57 which operates based on the command from a control system 51.
[0077] With the 4th operation gestalt, only the width of face (1/2 of the difference of an outer diameter and a bore) changes, without the main height (1/2 of the mean value of an outer diameter (diameter) and a bore (diameter)) of the zona-orbicularis-like secondary light source as a virtual image formed in the plane-of-incidence location of the fly eye lens 6 changing, if the scale factor of the afocal zoom lens 41 changes. That is, both the zona-orbicularis-like the magnitude (outer diameter) and its zona-orbicularis ratio (the bore/outer diameter) of the secondary light source can be changed by changing the scale factor of the afocal zoom lens 41.
[0078] Moreover, both main height and its width of face change, without the zona-orbicularis ratio of the secondary zona-orbicularis-like light source changing, if the focal distance of the 1st relay optical system 21 changes. That is, the outer diameter can be changed by changing the focal distance of the 1st relay optical system 21, without changing the zona-orbicularis ratio of the secondary zona-orbicularis-like light source. As mentioned above, zona-orbicularis-like the outer diameter and zona-orbicularis ratio of the secondary light source can be changed in independent, respectively by changing suitably the scale factor of the afocal zoom lens 41, and the focal distance of the 1st relay optical system 21.
[0079] Next, while replacing with the micro fly eye lens 40 for zona-orbicularis lighting and setting up micro fly eye lens 40a for 4 pole lighting all over an illumination-light way, 4 pole lighting obtained by replacing with 1st diffracted-light study component 20a for zona-orbicularis lighting, and setting up 1st diffracted-light study component 20b for 4 pole lighting all over an illumination-light way is explained. Micro fly eye lens 40a consists of microlenses which have the forward refractive power of the shape of a square of a large number arranged in all directions and densely. Therefore, the flux of light from each light source formed in the backside [micro fly eye lens 40a] focal plane turns into the emission flux of light which has a square-like cross section, respectively, and carries out incidence to the afocal zoom lens 41.
[0080] Incidence of the flux of light through the afocal zoom lens 41 is carried out to 1st diffracted-light study component 20b for 4 pole lighting. The emission flux of light from each light source formed in the backside [micro fly eye lens 40a] focal plane at this time is converged on 1st diffracted-light study component 20b, with a square-like cross section maintained. When the parallel flux of light which has the cross section of the shape of a rectangle centering on an optical axis AX carries out incidence of the 1st diffracted-light study component 20b for 4 pole lighting, it forms the optical intensity distribution of 4 punctiforms centering on an optical axis AX in the far field (Fraunhofer diffraction field). In addition, the square which connects these four points and is formed is a square centering on an optical axis AX.
[0081] Therefore, the flux of light through 1st diffracted-light study component 20b forms the optical intensity distribution based on the convolution of the four points and a square centering on an optical axis AX, i.e., the optical intensity distribution of the shape of 4 poles centering on an optical axis AX, (it consists of the surface light source of four square configurations) on the 2nd diffracted-light study component 22 through the 1st relay optical system 21. The flux of light through the 2nd diffracted-light study component 22 forms the secondary light source of the shape of 4 poles as a virtual image in the plane-of-incidence location of the fly eye lens 6

through the 2nd relay optical system 24. Corresponding to the switch to micro fly eye lens 40a from the micro fly eye lens 40, and the switch to 1st diffracted-light study component 20b from 1st diffracted-light study component 20a, the switch to 4 pole aperture diaphragm from a zona-orbicularis aperture diaphragm is performed.

[0082] In addition, 4 pole-like the magnitude and the configuration of the secondary light source can be similarly defined as the secondary zona-orbicularis-like light source. That is, make into an outer diameter the diameter of circle circumscribed to the four surface light sources which constitute the secondary 4 pole-like light source, and let the diameter of circle inscribed in the four surface light sources be a bore. In this way, both 4 pole-like the outer diameters and zona-orbicularis ratios of the secondary light source can be changed by changing the scale factor of the afocal zoom lens 41 like the case of zona-orbicularis lighting. Moreover, the outer diameter can be changed by changing the focal distance of the 1st relay optical system 21, without changing the zona-orbicularis ratio of the secondary 4 pole-like light source. Consequently, 4 pole-like the outer diameter and zona-orbicularis ratio of the secondary light source can be changed in independent, respectively by changing suitably the scale factor of the afocal zoom lens 41, and the focal distance of the 1st relay optical system 21.

[0083] Next, while evacuating both the micro fly eye lenses 40 and 40a from an illumination-light way, the circular lighting obtained by replacing with the 1st diffracted-light study components 20a or 20b, and setting up 1st diffracted-light study component 20c for circular lighting all over an illumination-light way is explained. in this case, on the afocal zoom lens 41, it has a rectangle-like cross section in accordance with an optical axis AX -- the parallel flux of light carries out incidence mostly. It is expanded or reduced according to the scale factor, and the flux of light which carried out incidence to the afocal zoom lens 41 is injected from the afocal zoom lens 41 in accordance with an optical axis AX with the flux of light which has a rectangle-like cross section, and carries out incidence to 1st diffracted-light study component 20c.

[0084] Here, when the parallel flux of light which has the cross section of the shape of a rectangle centering on an optical axis AX carries out incidence of the 1st diffracted-light study component 20c for circular lighting, it forms the optical intensity distribution of the circle configuration centering on an optical axis AX in the far field (Fraunhofer diffraction field). Therefore, the flux of light through 1st diffracted-light study component 20c forms the optical intensity distribution of the circle configuration centering on an optical axis AX on the 2nd diffracted-light study component 22 through the 1st relay optical system 21. The flux of light through the 2nd diffracted-light study component 22 forms the secondary light source of the circle configuration as a virtual image in the plane-of-incidence location of the fly eye lens 6 through the 2nd relay optical system 24.

[0085] In addition, corresponding to evacuation from the illumination-light way of the micro fly eye lenses 40 and 40a, and a setup on the illumination-light way of 1st diffracted-light study component 20c for circular lighting, the switch to a circular aperture diaphragm from a zona-orbicularis aperture diaphragm (or 4 pole aperture diaphragm) is performed. However, since the optical intensity distribution of a circle configuration are formed almost correctly on the 2nd diffracted-light study component 22 in this case, a setup on the illumination-light way of a circular aperture diaphragm is also omissible. And the magnitude (outer diameter) of the secondary light source of a circle configuration can be changed by changing suitably the scale factor of the afocal zoom lens 41, or the focal distance of the 1st relay optical system 21.

[0086] Or while setting micro fly eye lens 40a for 4 pole lighting as an illumination-light way, circular lighting can also be performed by evacuating the 1st diffracted-light study components 20a-20c from an illumination-light way. In addition, corresponding to a setup on the illumination-light way of micro fly eye lens 40a, and evacuation from the illumination-light way of the 1st diffracted-light study components 20a-20c, the switch to a circular aperture diaphragm from a zona-orbicularis aperture diaphragm (or 4 pole aperture diaphragm) is performed. In this case, the flux of light from each light source formed in the backside [micro fly eye lens 40a] focal plane forms optical square-like intensity distribution on the 2nd diffracted-light study component 22 through the afocal zoom lens 41 and the 1st relay optical system 21.

[0087] The flux of light through the 2nd diffracted-light study component 22 forms the secondary light source of the circle configuration as a virtual image in the plane-of-incidence location of the fly eye lens 6 through the 2nd relay optical system 24, after being restricted through a circular aperture diaphragm. And the magnitude (outer diameter) of the secondary light source of a circle configuration can be changed by changing suitably the scale factor of the afocal zoom lens 41, or the focal distance of the 1st relay optical system 21 also in this case.

[0088] Hereafter, switch actuation of the lighting conditions in the 4th operation gestalt etc. is explained concretely. First, the information about various kinds of masks which should carry out sequential exposure

according to step-and-repeat method or step - and - scanning method etc. is inputted into a control system 51 through the input means 50, such as a keyboard. The control system 51 has memorized information, such as optimal line breadth (resolution) about various kinds of masks, and the depth of focus, in the internal memory section, answers an input from the input means 50, and supplies the suitable control signal for the 1st drive system 52 - the 6th drive system 57.
[0089] That is, when carrying out zona-orbicularis lighting under the optimal resolution and the depth of focus, the 1st drive system 52 positions the micro fly eye lens 40 of zona-orbicularis lighting all over an illumination-light way based on the command from a control system 51. Moreover, the 3rd drive system 54 positions 1st diffracted-light study component 20a for zona-orbicularis lighting all over an illumination-light way based on the command from a control system 51. And in order to acquire the secondary light source of the shape of zona orbicularis which has desired magnitude (outer diameter) and a desired zona-orbicularis ratio in the plane-of-incidence location of the fly eye lens 6, the 2nd drive system 53 sets up the scale factor of the afocal zoom lens 41 based on the command from a control system 51, and the 4th drive system 55 sets up the focal distance of the 1st relay optical system 21 based on the command from a control system 51. Moreover, in order to restrict the flux of light from the 2nd diffracted-light study component 22 in the shape of zona orbicularis, the 5th drive system 56 rotates a turret based on the command from a control system 51, and positions a desired zona-orbicularis aperture diaphragm all over an illumination-light way. Moreover, the 6th drive system 57 drives the adjustable aperture diaphragm of projection optics PL based on the command from a control system 51 if needed.
[0090] Furthermore, zona-orbicularis-like the magnitude and the zona-orbicularis ratio of the secondary light source which are formed in the plane-of-incidence location of the fly eye lens 6 can be suitably changed if needed by changing the scale factor of the afocal zoom lens 41 by the 2nd drive system 53, or changing the focal distance of the 1st relay optical system 21 by the 4th drive system 55. In this case, a turret rotates according to change of the magnitude of the secondary zona-orbicularis-like light source, and a zona-orbicularis ratio, the zona-orbicularis aperture diaphragm which has desired magnitude and a desired zona-orbicularis ratio is chosen, and it is positioned all over an illumination-light way. In this way, zona-orbicularis-like the magnitude and the zona-orbicularis ratio of the secondary light source can be changed suitably, and various zona-orbicularis lighting can be performed.
[0091] moreover, the basis of the optimal resolution and the depth of focus -- 4 -- when illuminating very much, the 1st drive system 52 positions micro fly eye lens 40a for 4 pole lighting all over an illumination-light way based on the command from a control system 51. Moreover, the 3rd drive system 54 positions 1st diffracted-light study component 20b for 4 pole lighting all over an illumination-light way based on the command from a control system 51. And in order to acquire the secondary light source of the shape of 4 poles which has desired magnitude (outer diameter) and a desired configuration (zona-orbicularis ratio) in the plane-of-incidence location of the fly eye lens 6, the 2nd drive system 53 sets up the scale factor of the afocal zoom lens 41 based on the command from a control system 51, and the 4th drive system 55 sets up the focal distance of the 1st relay optical system 21 based on the command from a control system 51. Moreover, in order to restrict the flux of light from the 2nd diffracted-light study component 22 in the shape of 4 poles, the 5th drive system 56 rotates a turret based on the command from a control system 51, and positions desired 4 pole aperture diaphragm all over an illumination-light way. Moreover, the 6th drive system 57 drives the adjustable aperture diaphragm of projection optics PL based on the command from a control system 51 if needed.
[0092] Furthermore, 4 pole-like the magnitude and the configuration of the secondary light source which are formed in the plane-of-incidence location of the fly eye lens 6 can be suitably changed if needed by changing the scale factor of the afocal zoom lens 41 by the 2nd drive system 53, or changing the focal distance of the 1st relay optical system 21 by the 4th drive system 55. In this case, a turret rotates according to change of the magnitude of the secondary 4 pole-like light source, and a configuration, 4 pole aperture diaphragm which has desired magnitude and a desired configuration is chosen, and it is positioned all over an illumination-light way. In this way, 4 pole-like the magnitude and the configuration of the secondary light source can be changed suitably, and various 4 pole lighting can be performed.
[0093] Furthermore, when carrying out the circular lighting usual by the basis of the optimal resolution and the depth of focus, the 1st drive system 52 evacuates the micro fly eye lenses 40 and 40a from an illumination-light way based on the command from a control system 51, and the 3rd drive system 54 positions 1st diffracted-light study component 20c for circular lighting all over an illumination-light way based on the command from a control system 51. Or the 1st drive system 52 positions micro fly eye lens 40a all over an illumination-light way

based on the command from a control system 51, and the 3rd drive system 54 evacuates the 1st diffracted-light study components 20a-20c from an illumination-light way based on the command from a control system 51. And in order to acquire the secondary light source of the circle configuration which has desired magnitude (outer diameter) in the plane-of-incidence location of the fly eye lens 6, the 2nd drive system 53 sets up the scale factor of the afocal zoom lens 41 based on the command from a control system 51, and the 4th drive system 55 sets up the focal distance of the 1st relay optical system 21 based on the command from a control system 51. Moreover, the 5th drive system 56 rotates a turret based on the command from a control system 51, and positions a desired circular aperture diaphragm all over an illumination-light way. Moreover, the 6th drive system 57 drives the adjustable aperture diaphragm of projection optics PL based on the command from a control system 51 if needed.

[0094] Furthermore, the magnitude of the secondary light source of the circle configuration formed in the plane-of-incidence location of the fly eye lens 6 can be suitably changed if needed by changing the scale factor of the afocal zoom lens 41 by the 2nd drive system 53, or changing the focal distance of the 1st relay optical system 21 by the 4th drive system 55. In this case, a turret rotates according to change of the magnitude of the secondary light source of a circle configuration, the circular aperture diaphragm which has opening of desired magnitude is chosen, and it is positioned all over an illumination-light way. In this way, a sigma value can be changed suitably and various circular lighting can be performed. In addition, since the optical intensity distribution of a circle configuration are formed almost correctly on the 2nd diffracted-light study component 22 as mentioned above when using 1st diffracted-light study component 20c for circular lighting, a setup on the illumination-light way of a circular aperture diaphragm is also omissible.

[0095] In addition, although 4 pole lighting is performed with the 4th operation gestalt using micro fly eye lens 40a which consists of a square-like microlens, 4 pole lighting can also be performed using the micro fly eye lens 40 which consists of a forward hexagon-like microlens.

[0096] Drawing 12 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the 5th operation gestalt of this invention. Although the 5th operation gestalt has a configuration similar to the 4th operation gestalt, the physical relationship of the micro fly eye lens 40 and the 1st diffracted-light study component 20 is the 4th operation gestalt and reverse. Hereafter, the 5th operation gestalt is explained paying attention to difference with the 4th operation gestalt. In addition, in drawing 12 , it is set up so that illumination-light study equipment may perform zona-orbicularis lighting.

[0097] with the 5th operation gestalt, it was injected from the light source 1 -- the parallel flux of light carries out incidence to 1st diffracted-light study component 20a for zona-orbicularis lighting through the beam expander 2 and the bending mirror 3 mostly. When the parallel flux of light which has a rectangle-like cross section carries out incidence of the 1st diffracted-light study component 20a, it has the function which forms optical ring-like intensity distribution in the far field. 1st diffracted-light study component 20a is constituted free [insertion and detachment] to an illumination-light way, and a switch with 1st diffracted-light study component 20b for 4 pole lighting and 1st diffracted-light study component 20c for circular lighting is performed by the drive system 58 which operates based on the command from a control system 51.

[0098] incidence was carried out to 1st diffracted-light study component 20a -- mostly, incidence of the parallel flux of light is carried out to the afocal zoom lens 41, and it forms optical ring-like intensity distribution in the pupil surface. The light from the optical intensity distribution of the shape of this ring serves as the parallel flux of light mostly, is injected from the afocal zoom lens 41, and carries out incidence to the micro fly eye lens 40 which consists of a forward hexagon-like microlens. Maintaining 1st diffracted-light study component 20a and the plane of incidence of the micro fly eye lens 40 in a relation [**** / optical almost], and maintaining an afocal system (non-focal optical system), the afocal zoom lens 41 is constituted so that a scale factor can be continuously changed in the predetermined range.

[0099] In this way, the flux of light carries out incidence to the symmetry from across mostly to an optical axis AX at the plane of incidence of the micro fly eye lens 40. The flux of light which carried out incidence to the micro fly eye lens 40 is divided by the microlens of the shape of much forward hexagon two-dimensional, and the light source of the shape of one ring is formed in a backside [each microlens] focal plane, respectively. In addition, the micro fly eye lens 40 is constituted free [insertion and detachment] to an illumination-light way, and is constituted possible [micro fly eye lens 40b from which the focal distance of a microlens differs in the micro fly eye lens 40, and a switch]. The switch between the micro fly eye lens 40 and micro fly eye lens 40b is performed by the drive system 59 which operates based on the command from a control system 51.

[0100] The flux of light from the ring-like light source of a large number formed in the backside [the micro fly

eye lens 40] focal plane illuminates the 2nd diffracted-light study component 22 in superposition through the 1st relay optical system 21. The 1st relay optical system 21 is the zoom lens to which a focal distance can be continuously changed in the predetermined range, and has connected substantially the backside [the micro fly eye lens 40] focal plane, and the 2nd diffracted-light study component 22 to the relation of the Fourier transform. Therefore, on the 2nd diffracted-light study component 22, the optical intensity distribution based on the convolution of a ring and a forward hexagon, i.e., the optical intensity distribution of the shape of zona orbicularis centering on an optical axis AX, are formed.
[0101] The magnitude (outer diameter) of the optical intensity distribution of the shape of this zona orbicularis changes depending on the focal distance of the 1st relay optical system 21. After the flux of light through the 2nd diffracted-light study component 22 is restricted by the zona-orbicularis aperture diaphragm 23, incidence of it is carried out to the fly eye lens 6 through the 2nd relay optical system 24. In this way, the secondary light source of the shape of zona orbicularis as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6.
[0102] With the 5th operation gestalt, the outer diameter and a zona-orbicularis ratio can be changed by changing the scale factor of the afocal zoom lens 41, without changing the width of face of the secondary zona-orbicularis-like light source. Moreover, only the outer diameter can be changed by changing the focal distance of the 1st relay optical system 21, without changing the zona-orbicularis ratio of the secondary zona-orbicularis-like light source. Therefore, zona-orbicularis-like the outer diameter and zona-orbicularis ratio of the secondary light source can be changed in independent, respectively by changing suitably the scale factor of the afocal zoom lens 41, and the focal distance of the 1st relay optical system 21.
[0103] In addition, with the 5th operation gestalt, in order to reconcile miniaturization and reservation of good optical-character ability, the half width (angle of diffraction) alpha of the aperture angle of the injection flux of light from 1st diffracted-light study component 20a is set up more greatly than beta whenever [maximum angle-of-emergence / of the injection flux of light from each light source formed of the micro fly eye lens 40]. Hereafter, this point is explained briefly. First, according to the realistic numerical example, the half width (angle of diffraction) alpha of the aperture angle of the injection flux of light from 1st diffracted-light study component 20a is set up, for example within the limits of four - 7 times. This is because the inclination for the permeability to fall becomes remarkable while manufacture of 1st diffracted-light study component 20a will become difficult, if alpha becomes larger than 7 times.
[0104] Moreover, if alpha becomes larger than 7 times, the path of the afocal ZUZUMU lens 41 will become large, as a result equipment will be enlarged. Furthermore, since it is necessary to set up small the focal distance of the 1st relay optical system 21 in order to maintain the outer diameter of the secondary zona-orbicularis-like light source at a predetermined value if alpha becomes larger than 7 times, the necessary f number of the 1st relay optical system 21 will become small too much, and manufacture of the 1st relay optical system 21 will become difficult. On the contrary, since it is necessary to set up greatly the focal distance of the 1st relay optical system 21 in order to maintain the outer diameter of the secondary zona-orbicularis-like light source at a predetermined value if alpha becomes smaller than 4 times, the overall length of the 1st relay optical system 21 will become large, as a result equipment will be enlarged.
[0105] On the other hand, according to the realistic numerical example, beta is set up, for example within the limits of one - 3 times whenever [maximum angle-of-emergence / of the injection flux of light from each light source formed of the micro fly eye lens 40]. This is because it is necessary to set up small the focal distance of each microlens of the micro fly eye lens 40 so if beta becomes larger than 3 times, and it becomes difficult to give necessary curvature to each microlens, as a result manufacture of the micro fly eye lens 40 becomes difficult.
[0106] Moreover, since it is necessary to set up small the focal distance of the 1st relay optical system 21 in order to maintain the outer diameter of the secondary zona-orbicularis-like light source at a predetermined value if beta becomes larger than 3 times, the necessary f number of the 1st relay optical system 21 will become small too much, and manufacture of the 1st relay optical system 21 will become difficult. On the contrary, since it is necessary to set up greatly the focal distance of the 1st relay optical system 21 in order to maintain the outer diameter of the secondary zona-orbicularis-like light source at a predetermined value if beta becomes smaller than 1 time, the overall length of the 1st relay optical system 21 will become large, as a result equipment will be enlarged. In addition, also in 4 pole lighting and circular lighting which are mentioned later, it is desirable to satisfy relation with beta whenever [half width / of the aperture angle of the injection flux of light from the 1st diffracted-light study component / (angle of diffraction) alpha and maximum angle-of-emergence /

of thë injection flux of light from each light source formed of a micro fly eye lens].
[0107] By the way, the focal distance of each microlens of the micro fly eye lens 40 is set up so that the range of 1 / 2 - 2/3 can be covered and the zona-orbicularis ratio of the secondary light source can be changed continuously. On the other hand, the focal distance of each microlens of micro fly eye lens 40b is set up so that the range of 2 / 3 - 3/4 can be covered and the zona-orbicularis ratio of the secondary light source can be changed continuously. Therefore, it is able for the micro fly eye lens 40 to cover the range of 1 / 2 - 2/3, and to change the zona-orbicularis ratio of the secondary light source continuously in the state of drawing 12 set up all over the illumination-light way. Moreover, if it replaces with the micro fly eye lens 40 and micro fly eye lens 40b is set up all over an illumination-light way, it will become possible to cover the range of 2 / 3 - 3/4, and to change the zona-orbicularis ratio of the secondary light source continuously. In this way, it is possible to cover the range of 1 / 2 - 3/4, and to change the zona-orbicularis ratio of the secondary light source continuously with the 5th operation gestalt.
[0108] Next, 4 pole lighting obtained by replacing with 1st diffracted-light study component 20a for zona-orbicularis lighting, and setting up 1st diffracted-light study component 20b for 4 pole lighting all over an illumination-light way is explained briefly. In this case, the light intensity distribution of 4 punctiforms [flux of light / parallel / pupil surface / of the afocal zoom lens 41] almost which carried out incidence to 1st diffracted-light study component 20b are formed. The light from the optical intensity distribution of these 4 punctiforms serves as the parallel flux of light mostly, is injected from the afocal zoom lens 41, and carries out incidence to the micro fly eye lens 40 (or 40b). In this way, the one light source of 4 punctiforms is formed in a backside [each microlens of the micro fly eye lens 40 (or 40b)] focal plane, respectively.
[0109] The flux of light from 4 punctiform light source of a large number formed in the backside [the micro fly eye lens 40 (or 40b)] focal plane forms the optical intensity distribution based on the convolution of four points and a forward hexagon, i.e., the optical intensity distribution of the shape of 4 poles centering on an optical axis AX, (it consists of the surface light source of the shape of four forward hexagon) on the 2nd diffracted-light study component 22 through the 1st relay optical system 21. After the flux of light through the 2nd diffracted-light study component 22 is restricted by 4 pole aperture diaphragm, incidence of it is carried out to the fly eye lens 6 through the 2nd relay optical system 24. In this way, the secondary light source of the shape of 4 poles as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6.
[0110] With 4 pole lighting, both the outer diameter and a zona-orbicularis ratio can be changed by changing the scale factor of the afocal zoom lens 41 like the case of zona-orbicularis lighting, without changing the width of face of the secondary 4 pole-like light source. Moreover, only the outer diameter can be changed by changing the focal distance of the 1st relay optical system 21, without changing the zona-orbicularis ratio of the secondary 4 pole-like light source. Therefore, 4 pole-like the outer diameter and zona-orbicularis ratio of the secondary light source can be changed in independent, respectively by changing suitably the scale factor of the afocal zoom lens 41, and the focal distance of the 1st relay optical system 21.
[0111] Next, the circular lighting obtained by replacing with the 1st diffracted-light study components 20a or 20b, and setting up 1st diffracted-light study component 20c for circular lighting all over an illumination-light way is explained. in this case, incidence was carried out to 1st diffracted-light study component 20c -- the parallel flux of light forms the optical intensity distribution of a circle configuration in the pupil surface of the afocal zoom lens 41 mostly. The light from the optical intensity distribution of this circle configuration serves as the parallel flux of light mostly, is injected from the afocal zoom lens 41, and carries out incidence to the micro fly eye lens 40 (or 40b). In this way, the light source of one circle configuration is formed in a backside [each microlens of the micro fly eye lens 40 (or 40b)] focal plane, respectively.
[0112] The flux of light from the circle configuration light source of a large number formed in the backside [the micro fly eye lens 40 (or 40b)] focal plane forms the optical intensity distribution based on [being circular] a convolution with a forward hexagon, i.e., the optical intensity distribution of the circle configuration centering on an optical axis AX, on the 2nd diffracted-light study component 22 through the 1st relay optical system 21. After the flux of light through the 2nd diffracted-light study component 22 is restricted by the circular aperture diaphragm, incidence of it is carried out to the fly eye lens 6 through the 2nd relay optical system 24. In this way, the secondary light source of the circle configuration as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6. With circular lighting, the magnitude (outer diameter) of the secondary light source of a circle configuration can be changed by changing suitably the focal distance of the 1st relay optical system 21.
[0113] Drawing 13 is drawing showing roughly the configuration of the aligner equipped with the illumination-

light study equipment concerning the 6th operation gestalt of this invention. Although the 6th operation gestalt has a configuration similar to the 4th operation gestalt, only the configuration between the bending mirror 3 and the 1st relay optical system 21 is fundamentally different from the 4th operation gestalt. Hereafter, the 6th operation gestalt is explained paying attention to difference with the 4th operation gestalt. In addition, in drawing 13 , it is set up so that illumination-light study equipment may perform zona-orbicularis lighting.

[0114] with the 6th operation gestalt, it was injected from the light source 1 -- the parallel flux of light carries out incidence to 1st diffracted-light study component 60a for zona-orbicularis lighting through the beam expander 2 and the bending mirror 3 mostly. When the parallel flux of light which has a rectangle-like cross section carries out incidence of the 1st diffracted-light study component 60a, it has the function which forms optical zona-orbicularis-like (in a circle [have the shape not of a ring but predetermined width of face and]) intensity distribution in the far field (Fraunhofer diffraction field). in addition -- the -- one -- the diffracted light -- study -- a component -- 60 -- a -- the illumination light -- a way -- receiving -- insertion and detachment -- free -- constituting -- having -- four -- a pole -- lighting -- ** -- the -- one -- the diffracted light -- study -- a component -- 60 -- b -- circular -- lighting -- ** -- the -- one -- the diffracted light -- study -- a component -- 60 -- c -- a switch -- possible -- constituting -- having -- **** . The switch between 1st diffracted-light study component 60a, and 60b and 60c is performed by the drive system 65 which operates based on the command from a control system 51.

[0115] Incidence of the flux of light through 1st diffracted-light study component 60a is carried out to an afocal lens 61. An afocal lens 61 is the afocal system (non-focal optical system) set up so that the location of the predetermined side 63 which a before side focal location and the location of 1st diffracted-light study component 60a are mostly in agreement, and is shown by the after that side focal location and the drawing destructive line might be mostly in agreement. Here, the location of the predetermined side 63 is a location in which the 1st diffracted-light study components 20a-20c are installed in the 4th operation gestalt.

[0116] Therefore, mostly, after [which carried out incidence to 1st diffracted-light study component 60a] the parallel flux of light forms optical zona-orbicularis-like intensity distribution in the pupil surface of an afocal lens 61, it turns into the parallel flux of light mostly, and is injected from an afocal lens 61. In addition, although the prism members 62a and 62b of a pair are arranged in the optical path between before [an afocal lens 61] side lens group 61a, and backside lens group 61b, about the detailed configuration and detailed operation, it mentions later. Hereafter, in order to simplify explanation, an operation of the prism members 62a and 62b of a pair is disregarded, and the fundamental configuration and fundamental operation of the 6th operation gestalt are explained.

[0117] Incidence of the flux of light through an afocal lens 61 is carried out to the 2nd diffracted-light study component 22 through the 1st relay optical system 21. Here, the location of the predetermined side 63 is arranged near the before [the 1st relay optical system 21] side focal location, and the 2nd diffracted-light study component 22 is arranged near the backside [the 1st relay optical system 21] focal location. If it puts in another way, the 1st relay optical system 21 will have arranged substantially the predetermined side 63 and the 2nd diffracted-light study component 22 in the relation of the Fourier transform, as a result will arrange optically the pupil surface and the 2nd diffracted-light study component 22 of an afocal lens 61 to conjugate mostly.

[0118] Therefore, on the 2nd diffracted-light study component 22, the optical intensity distribution of the shape of zona.orbicularis centering on an optical axis AX are formed like the pupil surface of an afocal lens 61. The magnitude (outer diameter) of the optical intensity distribution of the shape of this zona orbicularis changes depending on the focal distance of the 1st relay optical system 21. After the flux of light through the 2nd diffracted-light study component 22 is restricted by the zona-orbicularis aperture diaphragm 23, incidence of it is carried out to the fly eye lens 6 through the 2nd relay optical system 24. In this way, the secondary light source of the shape of zona orbicularis as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6.

[0119] With the 6th operation gestalt, as mentioned above, the cone axicon 62 which consists of prism members 62a and 62b of a pair into the optical path between before [an afocal lens 61] side lens group 61a and backside lens group 61b is arranged. The cone axicon 62 consists of 2nd prism member 62b which turned the flat surface to 1st prism member 62a which turned the flat surface to the light source side, and turned the concave conic refracting interface to the mask side sequentially from the light source side, and a mask side, and turned the convex conic refracting interface to the light source side. And the concave conic refracting interface of 1st prism member 62a and the convex conic refracting interface of 2nd prism member 62b are

formed complementary so that it can contact mutually.
[0120] Moreover, one [at least] member is constituted movable in accordance with an optical axis AX among 1st prism member 62a and 2nd prism member 62b, and spacing of the concave conic refracting interface of 1st prism member 62a and the convex conic refracting interface of 2nd prism member 62b is constituted by adjustable. Change of spacing of the cone axicon 62 is performed by the drive system 66 which operates based on the command from a control system 51. In addition, although 1st prism member 62a which has a concave conic refracting interface sequentially from a light source side, and 2nd prism member 62b which has a convex conic refracting interface are arranged in drawing 13 , this location sequence can also be made reverse.
[0121] Here, in the condition that the concave cone-like refracting interface of 1st prism member 62a and the convex cone-like refracting interface of 2nd prism member 62b have contacted mutually, the cone axicon 62 functions as a plane-parallel plate, and there is no effect affect the secondary light source of the shape of zona orbicularis formed. However, if the concave cone-like refracting interface of 1st prism member 62a and the convex cone-like refracting interface of 2nd prism member 62b are made to estrange, the cone axicon 62 will function as the so-called beam expander. Therefore, the include angle of the incoming beams to the predetermined side 63 changes with change of spacing of the cone axicon 62. That is, the cone axicon 62 constitutes the modification component whenever [for changing whenever / incident angle / of the incoming beams to the predetermined side 63 / incident angle].
[0122] Consequently, the outer diameter and bore change, without the width of face of the secondary light source of the shape of zona orbicularis formed in the plane-of-incidence location of the fly eye lens 6 as a virtual image changing. In this way, with the 6th operation gestalt, the outer diameter and a zona-orbicularis ratio can be changed by changing spacing of the cone axicon 62, without changing the width of face of the secondary zona-orbicularis-like light source. Moreover, only the outer diameter can be changed by changing the focal distance of the 1st relay optical system 21, without changing the zona-orbicularis ratio of the secondary zona-orbicularis-like light source. Therefore, zona-orbicularis-like the outer diameter and zona-orbicularis ratio of the secondary light source can be changed in independent, respectively by changing suitably spacing of the cone axicon 62, and the focal distance of the 1st relay optical system 21.
[0123] Next, 4 pole lighting obtained by replacing with 1st diffracted-light study component 60a for zona-orbicularis lighting, and setting up 1st diffracted-light study component 60b for 4 pole lighting all over an illumination-light way is explained briefly. In this case, mostly, after [which carried out incidence to 1st diffracted-light study component 60b] the parallel flux of light forms optical 4 pole-like intensity distribution in the pupil surface of an afocal lens 61, it turns into the parallel flux of light mostly, and is injected from an afocal lens 61. The flux of light through an afocal lens 61 forms the optical intensity distribution of the shape of 4 poles centering on an optical axis AX in the 2nd diffracted-light study component 22 through the 1st relay optical system 21. The flux of light through the 2nd diffracted-light study component 22 forms the secondary light source of the shape of 4 poles as a virtual image in the plane-of-incidence location of the fly eye lens 6 through the 2nd relay optical system 24, after being restricted by 4 pole aperture diaphragm.
[0124] In this way, with 4 pole lighting of the 6th operation gestalt, the outer diameter and a zona-orbicularis ratio can be changed by changing spacing of the cone axicon 62, without changing the width of face of the secondary 4 pole-like light source. Moreover, only the outer diameter can be changed by changing the focal distance of the 1st relay optical system 21, without changing the zona-orbicularis ratio of the secondary 4 pole-like light source. Therefore, 4 pole-like the outer diameter and zona-orbicularis ratio of the secondary light source can be changed in independent, respectively by changing suitably spacing of the cone axicon 62, and the focal distance of the 1st relay optical system 21.
[0125] Furthermore, the circular lighting obtained by replacing with 1st diffracted-light study component 60a for zona-orbicularis lighting or 1st diffracted-light study component 60b for 4 pole lighting, and setting up 1st diffracted-light study component 60c for circular lighting all over an illumination-light way is explained briefly. In this case, mostly, after [which carried out incidence to 1st diffracted-light study component 60c] the parallel flux of light forms the optical intensity distribution of a circle configuration in the pupil surface of an afocal lens 61, it turns into the parallel flux of light mostly, and is injected from an afocal lens 61.
[0126] The flux of light through an afocal lens 61 forms the optical intensity distribution of the circle configuration centering on an optical axis AX in the 2nd diffracted-light study component 22 through the 1st relay optical system 21. The flux of light through the 2nd diffracted-light study component 22 forms the secondary light source of the circle configuration as a virtual image in the plane-of-incidence location of the fly eye lens 6 through the 2nd relay optical system 24, after being restricted by the circular aperture diaphragm.

With circular lighting, the magnitude (outer diameter) of the secondary light source of a circle configuration can be changed by changing the focal distance of the 1st relay optical system 21.

[0127] Drawing 14 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the 7th operation gestalt of this invention. Only the point that replace with a cone axicon and the V groove axicon of a pair is set up although the 7th operation gestalt has a configuration similar to the 6th operation gestalt is fundamentally different from the 6th operation gestalt. Hereafter, the 7th operation gestalt is explained paying attention to difference with the 6th operation gestalt. In addition, in drawing 14 , it is set up so that illumination-light study equipment may perform zona-orbicularis lighting.

[0128] With the 7th operation gestalt, mostly, after [when the parallel flux of light formed optical zona-orbicularis-like intensity distribution in the pupil surface of an afocal lens 61 through the beam expander 2, the bending mirror 3, and 1st diffracted-light study component 60a for zona-orbicularis lighting] being injected from the light source 1, it becomes the parallel flux of light mostly, and is injected from an afocal lens 61. In addition, although the 1st V groove axicon 71 which consists of prism members 71a and 71b of a pair, and the 2nd V groove axicon 72 which consists of prism members 72a and 72b of a pair are arranged in the optical path between before [an afocal lens 61] side lens group 61a, and backside lens group 61b, about the detailed configuration and detailed operation, it mentions later.

[0129] The flux of light through an afocal lens 61 forms the optical intensity distribution of the shape of zona orbicularis centering on an optical axis AX in the 2nd diffracted-light study component 22 through the 1st relay optical system 21. The flux of light through the 2nd diffracted-light study component 22 forms the secondary light source of the shape of zona orbicularis as a virtual image in the plane-of-incidence location of the fly eye lens 6 through the 2nd relay optical system 24, after being restricted by the zona-orbicularis aperture diaphragm 23. In addition, like the 6th operation gestalt, if the focal distance of the 1st relay optical system 21 changes, only the outer diameter will change, without the zona-orbicularis ratio of the secondary zona-orbicularis-like light source changing.

[0130] Drawing 15 is drawing showing roughly the configuration of the 1st V groove axicon arranged in the optical path of an afocal lens, and the 2nd V groove axicon. As shown in drawing 14 and drawing 15 , in the optical path of an afocal lens 61, the 1st V groove axicon 71 and the 2nd V groove axicon 72 are arranged sequentially from the light source side. The 1st V groove axicon 71 consists of 2nd prism member 71b which turned the flat surface to 1st prism member 71a which turned the flat surface to the light source side, and turned the concave refracting interface to the mask side, and a mask side, and turned the convex refracting interface to the light source side. The concave refracting interface of 1st prism member 71a consisted of two flat surfaces, and the intersection is prolonged along the direction of X.

[0131] If the convex refracting interface of 2nd prism member 71b is put in another way so that it can contact as mutually as the concave refracting interface of 1st prism member 71a, it is formed complementary with the concave refracting interface of 1st prism member 71a. That is, the convex refracting interface of 2nd prism member 71b also consisted of two flat surfaces, and the intersection is prolonged along the direction of X. Moreover, at least one side is constituted movable in accordance with an optical axis AX among 1st prism member 71a and 2nd prism member 71b, and spacing of the concave refracting interface of 1st prism member 71a and the convex refracting interface of 2nd prism member 71b is constituted by adjustable. In addition, change of spacing of the 1st V groove axicon 71 is performed by the drive system 75 which operates based on the command from a control system 51.

[0132] On the other hand, the 2nd V groove axicon 72 consists of 2nd prism member 72b which turned the flat surface to 1st prism member 72a which turned the flat surface to the light source side, and turned the concave refracting interface to the mask side, and a mask side, and turned the convex refracting interface to the light source side. The concave refracting interface of 1st prism member 72a consisted of two flat surfaces, and the intersection is prolonged along with the Z direction. The convex refracting interface of 2nd prism member 72b is formed as complementary as the concave refracting interface of 1st prism member 72a. That is, the convex refracting interface of 2nd prism member 72b also consisted of two flat surfaces, and the intersection is prolonged along with the Z direction. Moreover, at least one side is constituted movable in accordance with an optical axis AX among 1st prism member 72a and 2nd prism member 72b, and spacing of the concave refracting interface of 1st prism member 72a and the convex refracting interface of 2nd prism member 72b is constituted by adjustable. In addition, change of spacing of the 2nd V groove axicon 72 is performed by the drive system 76 which operates based on the command from a control system 51.

[0133] Here, in the condition that the concave refracting interface and convex refracting interface which

counter have contacted mutually, the 1st V groove axicon 71 and the 2nd V groove axicon 72 function as plane-parallel plates, and there is no effect affect the secondary light source of the shape of zona orbicularis formed. However, although the 1st V groove axicon 71 will function as a plane-parallel plate along the direction of X if it makes a concave refracting interface and a convex refracting interface estrange, it functions as a beam expander along with a Z direction. Moreover, although the 2nd V groove axicon 72 will function as a plane-parallel plate along with a Z direction if it makes a concave refracting interface and a convex refracting interface estrange, it functions as a beam expander along the direction of X. That is, the 1st V groove axicon 71 and the 2nd V groove axicon 72 constitute the aspect ratio modification component which changes the aspect ratio of incoming beams in order to change whenever [incident angle / which met in the predetermined direction of the incoming beams to the predetermined side 63].

[0134] Therefore, although whenever [incident angle / which met in the direction of X of the incoming beams to the predetermined side 63] does not change with change of spacing of the 1st V groove axicon 71, whenever [in alignment with the Z direction of the incoming beams to the predetermined side 63 / incident angle] changes. Consequently, as shown in drawing 16 (a), although each four surface light sources 81-84 of a four semicircle arc which constitute the secondary zona-orbicularis-like light source do not move in the direction of X, they move to a Z direction. That is, if spacing of the 1st V groove axicon 71 increases, the surface light sources 81 and 82 will move to + Z direction, and will move the surface light sources 83 and 84 to - Z direction.

[0135] On the other hand, although whenever [in alignment with the Z direction of the incoming beams to the predetermined side 63 / incident angle] does not change with change of spacing of the 2nd V groove axicon 72, whenever [incident angle / which met in the direction of X of the incoming beams to the predetermined side 63] changes. Consequently, as shown in drawing 16 (b), although each surface light sources 81-84 do not move to a Z direction, they move in the direction of X. Namely, if spacing of the 2nd V groove axicon 72 increases, the surface light sources 81 and 83 will move in the direction of -X, and will move the surface light sources 82 and 84 in the direction of +X.

[0136] Furthermore, change of both spacing of the 1st V groove axicon 71 and spacing of the 2nd V groove axicon 72 changes whenever [in alignment with whenever / incident angle / which met in the direction of X of the incoming beams to the predetermined side 63 / and, a Z direction / incident angle / both]. Consequently, as shown in drawing 16 (c), each surface light sources 81-84 move in a Z direction and the direction of X. Namely, if both spacing of the 1st V groove axicon 71 and spacing of the 2nd V groove axicon 72 increase, the surface light source 81 will move in + Z direction and the direction of -X, and the surface light source 82 moves in + Z direction and the direction of +X, the surface light source 83 will move in - Z direction and the direction of -X, and it will move the surface light source 84 in - Z direction and the direction of +X. In this way, the secondary light source of the shape of 4 poles which consists of the surface light source of the four shape of independent radii can be formed.

[0137] Moreover, zona-orbicularis lighting can be performed by replacing with 1st diffracted-light study component 60a for zona-orbicularis lighting, and setting up 1st diffracted-light study component 60b for 4 pole lighting all over an illumination-light way like the 6th operation gestalt. In this case, if spacing of the 1st V groove axicon 71 increases, as shown in drawing 17 (a), among the four surface light sources 85-88 which constitute the secondary 4 pole-like light source, the surface light sources 85 and 86 will move to + Z direction, and the surface light sources 87 and 88 will move them to - Z direction.

[0138] On the other hand, if spacing of the 2nd V groove axicon 72 increases, as shown in drawing 17 (b), the surface light sources 85 and 87 will move in the direction of -X, and will move the surface light sources 86 and 88 in the direction of +X. Furthermore, if both spacing of the 1st V groove axicon 71 and spacing of the 2nd V groove axicon 72 increase, as shown in drawing 17 (c), the surface light source 85 will move in + Z direction and the direction of -X, and the surface light source 86 moves in + Z direction and the direction of +X, the surface light source 87 will move in - Z direction and the direction of -X, and it will move the surface light source 88 in - Z direction and the direction of +X.

[0139] Furthermore, circular lighting can be performed by replacing with 1st diffracted-light study component 60a for zona-orbicularis lighting, or 1st diffracted-light study component 60b for 4 pole lighting, and setting up 1st diffracted-light study component 60c for circular lighting all over an illumination-light way like the 6th operation gestalt. In this case, if spacing of the 1st V groove axicon 71 increases, as shown in drawing 18 (a), the surface light sources 89a and 89b will move to + Z direction among 89d from surface light source 89a of the four shape of 4 semicircles which constitutes the secondary light source of a circle configuration, and the

surface light sources 89c and 89d will move to − Z direction.
[0140] On the other hand, if spacing of the 2nd V groove axicon 72 increases, as shown in drawing 18 (b), the surface light sources 89a and 89c will move in the direction of −X, and will move the surface light sources 89b and 89d in the direction of +X. Furthermore, if both spacing of the 1st V groove axicon 71 and spacing of the 2nd V groove axicon 72 increase, as shown in drawing 18 (c), surface light source 89a will move in + Z direction and the direction of −X, surface light source 89b will move in + Z direction and the direction of +X, surface light source 89c will move in − Z direction and the direction of −X, and 89d of surface light sources will move in − Z direction and the direction of +X. In this way, the secondary light source of the shape of 4 poles which consists of the surface light source of the four shape of independent 4 semicircles can be formed.
[0141] In addition, although the 1st V groove axicon 71 which functions as a beam expander along with a Z direction, and the 2nd V groove axicon 72 which functions as beam expanders along the direction of X are arranged sequentially from a light source side with the 7th operation gestalt, this location sequence can also be made reverse. Moreover, although the 1st prism member which has a concave conic refracting interface, and the 2nd prism which has a convex conic refracting interface are arranged sequentially from a light source side in the 1st V groove axicon 71 and the 2nd V groove axicon 72, this location sequence can also be made reverse.
[0142] Moreover, with the 7th operation gestalt, although the 1st V groove axicon 71 and the 2nd V groove axicon 72 consist of prism members of a pair, respectively, as shown in drawing 19 , the prism member 73 which made 2nd prism member 71b of the 1st V groove axicon 71 and 1st prism member 72a of the 2nd V groove axicon 72 unify can also be used, without being limited to this. In this case, spacing of the 1st V groove axicon 71 and spacing of the 2nd V groove axicon 72 can be independently changed, respectively by moving at least two members in accordance with an optical axis AX among 2nd prism member 72b of 1st prism member 71a of the 1st V groove axicon 71, the unification prism member 73, and the 2nd V groove axicon 72.
[0143] Furthermore, with the 7th operation gestalt, although the V groove axicons 71 and 72 of a pair are arranged in the optical path of an afocal lens 61, the cone axicon 62 of the 6th operation gestalt can also be attached, for example into the optical path between the 2nd V groove axicon 72 and backside [an afocal lens 61] lens group 61b. In this way, also in the 7th operation gestalt, the outer diameter and zona-orbicularis ratio of the secondary light source of the shape of the shape of zona orbicularis or 4 poles can be changed in independent like the 6th operation gestalt, respectively by changing suitably spacing of the cone axicon 62, and the focal distance of the 1st relay optical system 21.
[0144] In this case, while using the prism member 73 which made 2nd prism member 71b of the 1st V groove axicon 71, and 1st prism member 72a of the 2nd V groove axicon 72 unify, the prism member 74 (un-illustrating) which made 2nd prism member 72b of the 2nd V groove axicon 72 and 1st prism member 62a of the cone axicon 62 unify can be used. And spacing of the 1st V groove axicon 71, spacing of the 2nd V groove axicon 72, and spacing of the cone axicon 62 can be independently changed, respectively by moving at least three members in accordance with an optical axis AX among 2nd prism member 62b of 1st prism member 71a of the 1st V groove axicon 71, the unification prism member 73, the unified prism member 74, and the cone axicon 62.
[0145] Furthermore, although the optical member is not arranged with the 6th operation gestalt and the 7th operation gestalt in the optical path between an afocal lens 61 and the 1st relay optical system 21, the modification which arranges a micro fly eye lens in the location of the predetermined side 63 is also possible. In this modification, it is set up so that a backside [an afocal lens 61] focal location and the plane of incidence of a micro fly eye lens may be mostly in agreement and a before [the 1st relay optical system 21] side focal location and the injection side of a micro fly eye lens may be mostly in agreement. And a diffracted-light study component which forms optical ring-like (4 punctiforms) intensity distribution in the far field as a 1st diffracted-light study component for zona-orbicularis lighting (for 4 pole lighting) is used.
[0146] Here, when the cross-section configuration of each microlens which constitutes a micro fly eye lens is a forward hexagon, the optical intensity distribution based on the convolution of a ring (four points) and a forward hexagon, i.e., the optical intensity distribution of the shape of zona orbicularis centering on an optical axis AX (the shape of 4 poles), are formed in the 2nd diffracted-light study component 22. The flux of light through the 2nd diffracted-light study component 22 forms the secondary light source of the shape of zona orbicularis as a virtual image (the shape of 4 poles) in the plane-of-incidence location of the fly eye lens 6 through the 2nd relay optical system 24, after being restricted by the zona-orbicularis aperture diaphragm 23 (4 pole aperture diaphragm). In addition, in this modification, it can replace with an afocal lens 61 and the afocal zoom lens 41 in the 4th operation gestalt and the 5th operation gestalt can also be used.

[0147] Next, in the illumination-light study equipment of each operation gestalt, the adjustment actuation for optimizing the lighting property is explained. Here, its attention is paid to dispersion (henceforth "illuminance unevenness") of the illumination distribution of the exposure light in the lighting field on Mask M (as a result, exposure field on Wafer W), and the amount of collapse of the tele cent rucksack nature of the exposure light to Mask M (henceforth "lighting TERESEN") as a lighting property of illumination-light study equipment. This is because these two lighting properties have biggest effect to the photoresist on the projection image by projection optics PL, and Wafer W.
[0148] And illuminance unevenness is divided into the primary component (this is called an "inclination component") about the location of the non-scanning direction (direction which intersects perpendicularly with a scanning direction) of an exposure field, and the secondary component (this is called "a concavo-convex component") about the location. Here, since the illuminance unevenness component of a scanning direction is equalized by scan exposure, it has not been made especially applicable to adjustment. The concavo-convex component of illuminance unevenness is a symmetrical component (axial symmetry component) about an optical axis. Moreover, lighting TERESEN is divided into the inclination component (shift component) corresponding to the tilt angle to the average direction of X and the direction of Y of exposure light of in a lighting field (exposure field), and the scale-factor component corresponding to a radial average tilt angle to the optical axis of exposure light.
[0149] First, in order to measure illuminance unevenness, the glass substrate with which a pattern is not formed instead of Mask M is installed. And exposure light is irradiated to the lighting field, it scans to a non-scanning direction by the light sensing portion of an illuminance unevenness sensor in the field corresponding to the exposure field of Wafer W, and the detecting signal of an illuminance unevenness sensor is incorporated. In addition, the field in which the mark for evaluation in the field in which the pattern of Mask M is not formed instead of or the evaluation mark plate mentioned later is not formed may be used. [the glass substrate with which a pattern is not formed] In this way, it can ask for the inclination component and the concavo-convex component of illuminance unevenness based on the obtained detecting-signal curve.
[0150] On the other hand, in order to measure lighting TERESEN, an evaluation mark plate is installed in the location of Mask M, and the scan plate of a space image measurement system is installed near the field corresponding to the exposure field of Wafer W. And only +delta sets up the focal location of a scan plate highly from the image surface (best focus location) over projection optics PL (delta is beforehand set up within limits from which predetermined resolution is obtained), the exposure of exposure light is started, and the image of the mark for evaluation of an evaluation mark plate is projected on a wafer stage. In this condition, the image of the mark for evaluation is scanned in the direction of X, and the direction of Y by the opening pattern of a scan plate, and the location of the direction of X of those images and the direction of Y is computed by processing the detecting signal obtained.
[0151] Next, it is a best focus location about the focal location of a scan plate. - Only delta is set up low and it asks for the location of the direction of X of the image of the mark for evaluation, and the direction of Y using a space image measurement system similarly. In this way, the inclination component of lighting TERESEN can be calculated from the average shift amount of the image of the mark for evaluation to the variation of the focal location of a scan plate. Moreover, the scale-factor component of lighting TERESEN can be calculated from the average shift amount to radial [of the image of those marks for evaluation].
[0152] With each above-mentioned operation gestalt, illuminance unevenness and lighting TERESEN are measured on the occasion of a switch of lighting conditions if needed. Here, with a switch of lighting conditions, the magnitude (outer diameter) of the secondary light source in the switch, zona-orbicularis lighting, or 4 pole lighting between zona-orbicularis lighting, 4 pole lighting, and circular lighting or modification of a configuration (zona-orbicularis ratio), modification of the magnitude (outer diameter) of the secondary light source in circular lighting, etc. are included. By measurement of illuminance unevenness, the inclination component (primary component) of illuminance unevenness and the concavo-convex component (secondary component) of illuminance unevenness are computed. Moreover, the inclination component (shift component) of lighting TERESEN and the scale-factor component of lighting TERESEN are computed by measurement of lighting TERESEN.
[0153] Next, each component of the computed illuminance unevenness and lighting TERESEN judges whether it is the inside of tolerance, respectively, and adjustment actuation is performed when which component has separated from tolerance. When the inclination component of illuminance unevenness has exceeded tolerance, specifically, what is done for the tilt of some of lenses or lens groups to an optical axis AX among two or more

lenses which constitute a condenser lens 7 (it leans) adjusts the inclination component of illuminance unevenness. Moreover, when the concavo-convex component of illuminance unevenness has exceeded tolerance, the concavo-convex component of illuminance unevenness is adjusted by rotating the neutral density filter plate (filter plate with which the pattern of predetermined permeability distribution was formed) arranged near the conjugation side of Mask M in the optical path between a condenser lens 7 and the mask blind 8 to the circumference of an optical axis AX.
[0154] Furthermore, when the inclination component of lighting TERESEN has exceeded tolerance, what some of lenses or lens groups are shifted for two-dimensional along a field perpendicular to an optical axis AX among two or more lenses which constitute a condenser lens 7 (it is made to move) adjusts the inclination component of lighting TERESEN. In addition, when the scale-factor component of lighting TERESEN has exceeded tolerance, in the light of the conventional technique, how to adjust the scale-factor component of lighting TERESEN can be considered by moving the fly eye lens 6 in accordance with an optical axis AX.
[0155] However, unlike the conventional technique in which the secondary light source is formed in a backside [the fly eye lens 6] focal location, with each above-mentioned operation gestalt, the secondary light source as a virtual image is formed in the plane-of-incidence location of the fly eye lens 6. Consequently, even if it moves only the fly eye lens 6 in accordance with an optical axis AX, the scale-factor component of lighting TERESEN cannot be adjusted. So, with the 2nd operation gestalt - 7th operation gestalt, the scale-factor component of lighting TERESEN is adjusted by moving the 2nd diffracted-light study component 22 and the fly eye lens 6 in accordance with an optical axis AX. Moreover, with both the 1st operation gestalten, the scale-factor component of lighting TERESEN is adjusted by moving the diffracted-light study component 4 and the fly eye lens 6 in accordance with an optical axis AX.
[0156] When the 2nd relay optical system 24 (relay optical system 5) is actual size, specifically, the scale-factor component of lighting TERESEN is adjusted by moving the 2nd diffracted-light study component 22 (diffracted-light study component 4) and the fly eye lens 6 in one. Moreover, according to the scale factor of the 2nd relay optical system 24 (relay optical system 5), when the 2nd relay optical system 24 (relay optical system 5) is non-actual size, when only the specified quantity moves the 2nd diffracted-light study component 22 (diffracted-light study component 4) and the fly eye lens 6, respectively, the scale-factor component of lighting TERESEN is adjusted.
[0157] Then, illuminance unevenness and lighting TERESEN are re-measured, and each component of the measured illuminance unevenness and lighting TERESEN judges whether it is the inside of tolerance, respectively. When which component has separated from tolerance, above-mentioned adjustment actuation is repeated. On the other hand, adjustment actuation is ended when all the components are settled in tolerance. In addition, when the same lighting conditions as a degree are set up by automating above-mentioned measurement actuation and adjustment actuation, based on the adjustment data memorized, measurement and adjustment of a lighting property can be completed extremely in a short time.
[0158] By the way, in each above-mentioned operation gestalt, it can replace with the 2nd diffracted-light study component 22 (or diffracted-light study component 4), for example, a micro fly eye lens can be used. In this case, if the number of wavefront splitting is increased by setting up small the size of each microlens element which constitutes this micro fly eye lens, the spatial coherency of two light through two adjoining microlens elements will become high, and a speckle-like interference fringe will occur on Mask M and Wafer W, as a result the homogeneity of illumination distribution will get worse. So, with each above-mentioned operation gestalt, homogeneous aggravation of the illumination distribution resulting from a speckle-like interference fringe can be suppressed good by constituting a micro fly eye lens from two kinds of microlens elements with which optical thickness differs in accordance with an optical axis AX.
[0159] Drawing 20 is drawing showing the important section configuration of the micro fly eye lens which consisted of two kinds of microlens elements with which optical thickness differs in accordance with an optical axis AX. By the micro fly eye lens 90 replaced with and used for the 2nd diffracted-light study component 22 (or diffracted-light study component 4), specifically So that the phase contrast between the light through small microlens element 90a of optical thickness and the light through large microlens element 90b of optical thickness may become 180 degrees in the fly eye lens 6 The difference of the optical thickness of two kinds of microlens elements 90a and 90b can be set up.
[0160] For example, when using an ArF excimer laser for the light source 1 and using the same optical material (a quartz or fluorite) as each microlens element which constitutes the micro fly eye lens 90, the difference of the thickness of two kinds of microlens elements is set up about 0.2 micrometers or odd times (3 times, 5

times; ..) of those. In addition, even if it sets up the thickness of each microlens element uniformly by using the optical material (a single optical material or compound optical material) with which refractive indexes differ for two kinds of microlens elements which constitute the micro fly eye lens 90 depending on the case, the difference of desired optical thickness is securable among two kinds of microlens elements.

[0161] Drawing 21 is drawing showing the example of arrangement of two kinds of microlens elements which constitute the micro fly eye lens of drawing 20 . In drawing 21 , the slash section shows small microlens element 90a of optical thickness, and the null section shows large microlens element 90b of optical thickness. In the example of arrangement of drawing 21 (a), the combination which the equal microlens element of optical thickness adjoins mutually, and the combination which the microlens element with which optical thickness differs adjoins mutually have the same number along 4 of each horizontal direction, each vertical direction, and the direction of each set angle (the direction of upward-slant-to-the-right slant, and the direction of left riser slant) directions.

[0162] Here, the light through two equal adjoining microlens elements of optical thickness forms a speckle-like interference fringe on the mask M which is an irradiated plane, and Wafer W. Since only the short optical-path-length difference (for example, 1/10 or less optical-path-length difference of time coherence length) is given more substantially than time coherence length, the light which, on the other hand, minded two adjoining microlens elements from which optical thickness differs also forms a speckle-like interference fringe on Mask M and Wafer W. However, a phase will shift in the speckle-like interference fringe which the light, i.e., the light of an opposite phase, through two adjoining microlens elements in which optical thickness differs from the speckle-like interference fringe to form, the light, i.e., a light in phase, through two equal adjoining microlens elements of optical thickness, forms.

[0163] Consequently, two speckle-like interference fringes from which a phase differs mutually overlap, each other is offset mutually, and the contrast of a synthetic interference fringe is reduced. According to the example of arrangement especially shown in drawing 21 (a), as mentioned above, the combination which the equal microlens element of optical thickness adjoins mutually, and the combination which the microlens element with which optical thickness differs adjoins mutually have the same number along four directions. Therefore, homogeneous aggravation of the illumination distribution which originates in the maximum at a speckle-like interference fringe using the phase bactericidal action of two speckle-like interference fringes from which a phase differs mutually can be suppressed good.

[0164] On the other hand, in the example of arrangement of drawing 21 (b), although the combination which the equal microlens element of optical thickness adjoins mutually, and the combination which the microlens element with which optical thickness differs adjoins mutually are not the same number even if it meets which direction among four directions, on the whole, it is quite equal along each direction. Therefore, in the example of arrangement of drawing 21 (b) as well as the case of the example of arrangement of drawing 21 (a), homogeneous aggravation of the illumination distribution resulting from a speckle-like interference fringe can be suppressed good using the phase bactericidal action of two speckle-like interference fringes from which a phase differs mutually.

[0165] Moreover, in the case of the example of arrangement of drawing 21 (b), the whole arrangement pattern is very regular, and is simple, and manufacture of the micro fly eye lens 90 is easy. In addition, although illustration was omitted, homogeneous aggravation of the illumination distribution resulting from a speckle-like interference fringe can be suppressed good using the phase bactericidal action of two speckle-like interference fringes from which a phase differs mutually like the case of the example of arrangement of drawing 21 (a), and the example of arrangement of drawing 21 (b) by arranging at random two kinds of microlens elements with which optical thickness differs.

[0166] In addition, although it replaces with the 2nd diffracted-light study component 22 (or diffracted-light study component 4) and one micro fly eye lens 90 is used in above-mentioned explanation, the micro fly eye lens of the pair which separated spacing in accordance with the optical axis AX can also be used. In this case, only the micro fly eye lens by the side of the light source may constitute a phase contrast grant means, and only the micro fly eye lens by the side of a mask may constitute a phase contrast grant means, and may constitute a phase contrast grant means by collaboration of both micro fly eye lenses.

[0167] Moreover, although the micro fly eye lens constitutes the phase contrast grant means from above-mentioned explanation, a phase contrast grant means can also consist of cover glass which has arranged cover glass to the light source or mask side, and has been arranged at the light source side, cover glass arranged at the mask side, or both cover glass. For example, when it constitutes a phase contrast grant means from one

cover glass arranged at the light source or mask side, this cover glass is formed so that it may have the minute field of the 1st group through which the flux of light of the 1st group passes, and the minute field of the 2nd group through which the flux of light of the 2nd group passes and may have the optical thickness from which the minute field of the 1st group and the minute field of the 2nd group differ mutually in accordance with an optical axis. A paraphrase will form cover glass as the so-called phase plate. According to this viewpoint, a phase contrast grant means can also consist of other phase plates arranged all over an illumination-light way.
[0168] Furthermore, although two kinds of microlens elements with which optical thickness differs constitute the micro fly eye lens from above-mentioned explanation, about the number of classes of the microlens element which constitutes a micro fly eye lens, it can also be set or more as three. Therefore, also in a phase plate, three or more kinds of minute fields where optical thickness differs can also be formed. In this case, the many light sources formed of a micro fly eye lens It has the light source group of the 1st group - the 3rd group. Between the flux of light of the 1st group, and the flux of lights of the 2nd group, So that only the respectively same amount may give phase contrast (phase contrast of 120 degrees) between the flux of light of the 1st group, and the flux of lights of the 3rd group, and to between the flux of light of the 3rd group, and the flux of lights of the 2nd group A micro fly eye lens considers as the configuration which has three sorts of very small lenses with which optical thickness differs, and, as for a phase plate, it is desirable to consider as the configuration which has three sorts of very small fields where optical thickness differs. As for the maximum of the optical optical-path-length difference in the whole micro fly eye lens given when the optical thickness of three sorts of very small lenses differs, at this time, it is much more desirable that it is 1/10 or less [of the time coherence length of the flux of light]. As for the maximum of the optical optical-path-length difference in the whole phase plate which similarly is given when the optical thickness of three sorts of very small fields differs with a phase plate, it is much more desirable that it is 1/10 or less [of question-coherence length] at the time of the flux of light.
[0169] Moreover, although two kinds of microlens elements with which optical thickness differs constitute the micro fly eye lens from above-mentioned explanation, it can also set up so that it may have the focal distance from which two kinds of this microlens element differs mutually. In this case, the light through the comparatively long microlens element of a focal distance will differ in the lighting area size formed on the mask M which is an irradiated plane from the light through the comparatively short microlens element of a focal distance. Consequently, it becomes possible to control the illumination distribution in the circumference of a lighting field through two or more kinds of microlens elements which have a mutually different focal distance.
[0170] Furthermore, although two kinds of microlens elements with which optical thickness differs constitute the micro fly eye lens from above-mentioned explanation, it can also set up so that two kinds of microlens elements may have the plane of incidence from which magnitude differs mutually. In this case, since the plane of incidence of the microlens element which constitutes a micro fly eye lens is optically arranged with the irradiated plane conjugate, the light through the comparatively large microlens element of plane of incidence will differ in the lighting area size formed on the mask M which is an irradiated plane from the light through the comparatively small microlens element of plane of incidence. Consequently, it becomes possible to control the illumination distribution in the circumference of a lighting field through two or more kinds of microlens elements which have the plane of incidence from which magnitude differs mutually.
[0171] Moreover, although it replaces with the 2nd diffracted-light study component 22 (or diffracted-light study component 4) and the micro fly eye lens is used in above-mentioned explanation, when using the diffracted-light study component of a Fresnel lens mold, homogeneous aggravation of the illumination distribution resulting from a speckle-like interference fringe may take place similarly. In this case, a phase contrast grant means can also consist of cover glass with which the diffracted-light study component of a Fresnel lens mold itself could constitute the phase contrast grant means, it has arranged cover glass to the that light source or mask side, and has been arranged at the light source side, cover glass arranged at the mask side, or both cover glass.
[0172] In the aligner concerning each above-mentioned operation gestalt, a mask (reticle) can be illuminated with illumination-light study equipment (lighting process), and micro devices (a semiconductor device, an image sensor, a liquid crystal display component, thin film magnetic head, etc.) can be manufactured by what (exposure process) the pattern for an imprint formed in the mask using projection optics is exposed for to a photosensitive substrate. Hereafter, by forming a predetermined circuit pattern in the wafer as a photosensitive substrate etc. using the aligner of each operation gestalt explains with reference to the flow chart of drawing 22 per example of the technique at the time of obtaining the semiconductor device as a micro device.

[0173] First, in step 301 of drawing 22 , a metal membrane is vapor-deposited on the wafer of one lot. In the following step 302, a photoresist is applied on the metal membrane on the wafer of the I lot. Then, in step 303, the sequential exposure imprint of the image of the pattern on a mask is carried out to each shot field on the wafer of the one lot through the projection optics using the aligner of each operation gestalt. Then, in step 304, after development of the photoresist on the wafer of the one lot is performed, in step 305, the circuit pattern corresponding to the pattern on a mask is formed in each shot field on each wafer by etching by using a resist pattern as a mask on the wafer of the one lot. Then, devices, such as a semiconductor device, are manufactured by performing formation of the circuit pattern of the upper layer etc. further. According to the above-mentioned semiconductor device manufacture approach, the semiconductor device which has a very detailed circuit pattern can be obtained with a sufficient throughput.
[0174] Moreover, in the aligner of each operation gestalt, the liquid crystal display component as a micro device can also be obtained by forming predetermined patterns (a circuit pattern, electrode pattern, etc.) on a plate (glass substrate). Hereafter, with reference to the flow chart of drawing 23 , it explains per example of the technique at this time. In drawing 23 , the so-called optical lithography process which carries out imprint exposure of the pattern of a mask at photosensitive substrates (glass substrate with which the resist was applied) is performed at the pattern formation process 401 using the aligner of each operation gestalt. Of this optical lithography process, the predetermined pattern containing many electrodes etc. is formed on a photosensitive substrate. Then, by passing through each process, such as a development process, an etching process, and a reticle exfoliation process, a predetermined pattern is formed on a substrate and the exposed substrate shifts to the following color filter formation process 402.
[0175] Next, in the color filter formation process 402, many groups of three dots corresponding to R (Red), G (Green), and B (Blue) are arranged in the shape of a matrix, or form the color filter which arranged the group of three filters, R, G, and B, of a stripe in the direction of two or more horizontal scanning line. And 403 is performed for a cel assembler after the color filter formation process 402. A cel assembler assembles a liquid crystal panel (liquid crystal cell) in 403 using the substrate which has the predetermined pattern obtained at the pattern formation process 401, the color filter obtained with the color filter formation process 402. In 403, a cel assembler pours in liquid crystal between the substrate which has the predetermined pattern obtained at the pattern formation process 401, for example, and the color filter obtained with the color filter formation process 402, and manufactures a liquid crystal panel (liquid crystal cell).
[0176] Then, a module assembler attaches each part articles in which the display action of the assembled liquid crystal panel (liquid crystal cell) is made to perform, such as an electrical circuit and a back light, and makes it complete as a liquid crystal display component in 404. According to the manufacture approach of an above-mentioned liquid crystal display component, the liquid crystal display component which has a very detailed circuit pattern can be obtained with a sufficient throughput.
[0177] In addition, in each above-mentioned operation gestalt, although many lens elements are accumulated and the fly eye lens 6 is formed, it is also possible to replace with the fly eye lens 6 and to use a micro fly eye lens. A micro fly eye lens establishes two or more very small lens sides in a light transmission nature substrate in the shape of a matrix by technique, such as etching. Although there is no difference in a function between a fly eye lens and a micro fly eye lens substantially about the point which forms two or more light source images, it is points, like that magnitude of opening of one element lens (very small lens) can be made very small, that a manufacturing cost is sharply reducible, and thickness of the direction of an optical axis can be made very thin, and a micro fly eye lens is advantageous.
[0178] Moreover, although each above-mentioned operation gestalt explained this invention taking the case of the projection aligner equipped with illumination-light study equipment, it is clear that this invention is applicable to the common illumination-light study equipment for illuminating irradiated planes other than a mask. By the way, the detailed explanation about the diffracted-light study component which can be used by this invention is indicated by the U.S. Pat. No. 5,850,300 official report etc. In addition, in each above-mentioned operation gestalt, as optically as an irradiated plane, since the plane of incidence of the fly eye lens 6 is conjugation mostly, it can amend the lighting unevenness in an irradiated plane and/or an irradiated plane, and a location [****] by arranging the optical member which adjusted permeability to the plane of incidence of the fly eye lens 6, or the location of the near. Concentration may change continuously and such an optical member may control permeability by the number of a dot. In addition, such an optical member is indicated by for example, the U.S. Pat. No. 5,615,047 official report, and JP,11-54417,A and a U.S. Pat. No. 6,049,374 official report.
[0179] Now, in each above-mentioned operation gestalt, since wavelength, such as KrF excimer laser

(wavelength: 248nm) and ArF excimer laser (wavelength: 193nm), uses exposure light 180nm or more as the light source, a diffracted-light study component can be formed with quartz glass. in addition, in using the wavelength of 200nm or less as an exposure light The quartz glass with which the quartz glass with which the fluorite and the fluorine were doped, a fluorine, and hydrogen were doped in the diffracted-light study component, Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose OH radical concentration is 1000 ppm or more, Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose hydrogen content child concentration is three or more 1x1017 molecules/cm, Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose level of chlorine is 50 ppm or less, And it is desirable to form with the ingredient chosen from the group of the quartz glass whenever [whose / structure decision constant temperature] are 1200K or less and, whose hydrogen content child concentration is three or more 1x1017 molecules/cm and, and whose level of chlorine is 50 ppm or less.

[0180] in addition, about the quartz glass whenever [whose / structure decision constant temperature] are 1200K or less and whose OH radical concentration is 1000 ppm or more It is indicated by the patent No. 2770224 official report by the applicant for this patent. Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose hydrogen content child concentration is three or more 1x1017 molecules/cm, Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose level of chlorine is 50 ppm or less, And whenever [structure decision constant temperature] is indicated by the 1200 according to applicant for this patent about quartz glass whose hydrogen content child concentration are K or less and is three or more 1x1017 molecules/cm and whose level of chlorine is 50 ppm or less patent No. 2936138 official report.

[0181]

[Effect of the Invention] As explained above, with the illumination-light study equipment of this invention, lighting conditions can be changed almost continuously, without carrying out quantity of light loss substantially in an optical integrator, if the injection side of an optical integrator is illuminated by the predetermined ratio since the secondary light source of the predetermined configuration as a virtual image is formed in the plane-of-incidence location of the optical integrator of a wavefront-splitting mold.

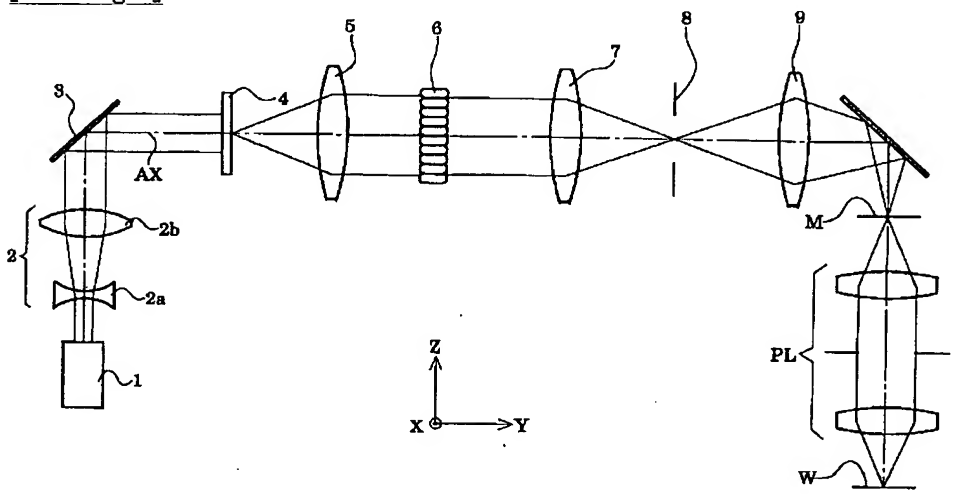
[0182] Therefore, with the aligner incorporating the illumination-light study equipment of this invention, since lighting conditions can be changed almost continuously, without carrying out quantity of light loss substantially in an optical integrator, a good micro device can be manufactured under good lighting conditions at a high throughput.

[Translation done.]

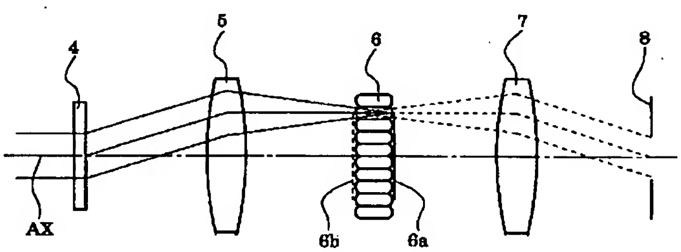
* NOTICES *

DRAWINGS

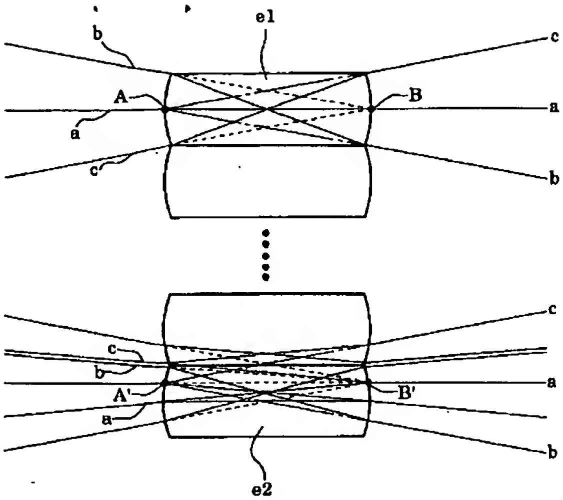
[Drawing 1]



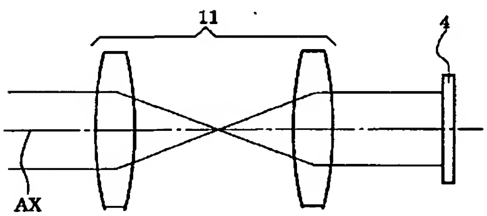
[Drawing 2]



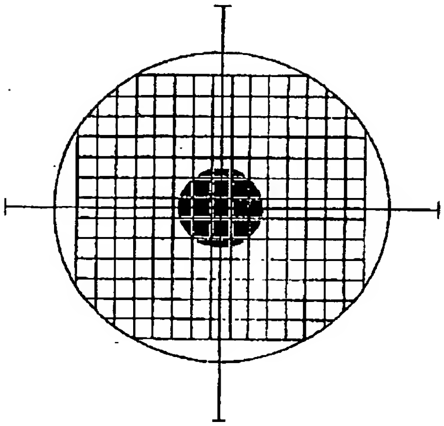
[Drawing 3]



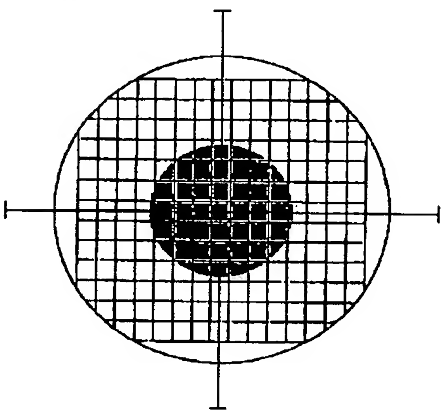
[Drawing 4]



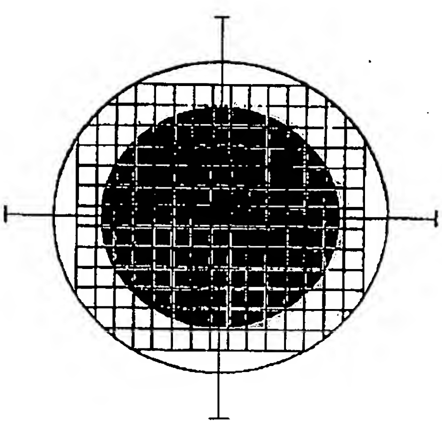
[Drawing 5]



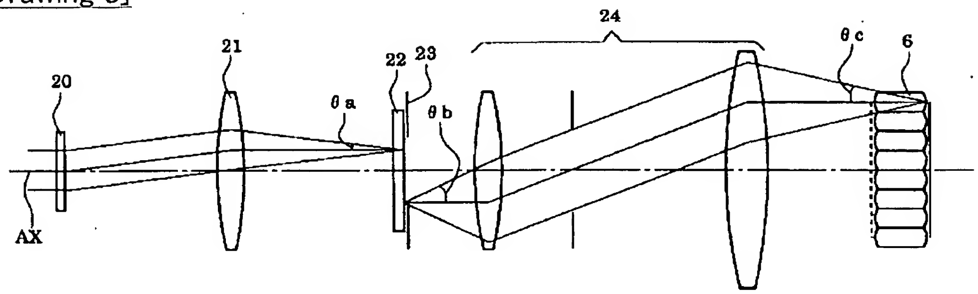
[Drawing 6]



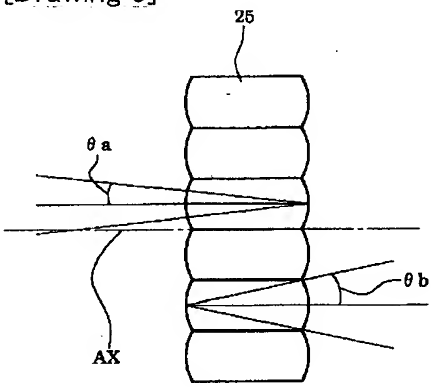
[Drawing 7]



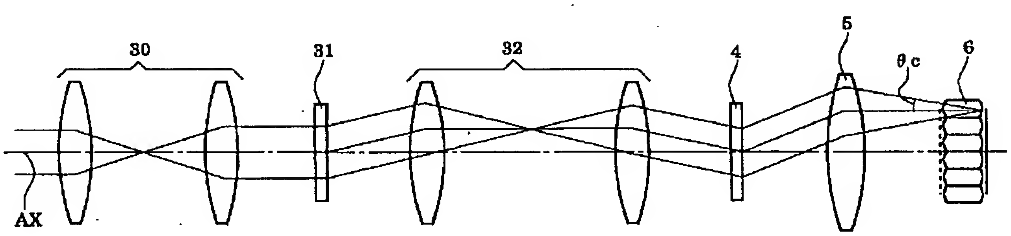
[Drawing 8]



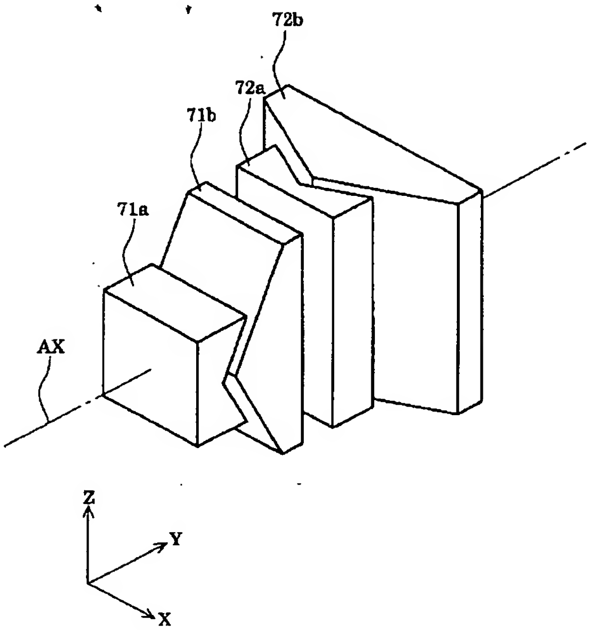
[Drawing 9]



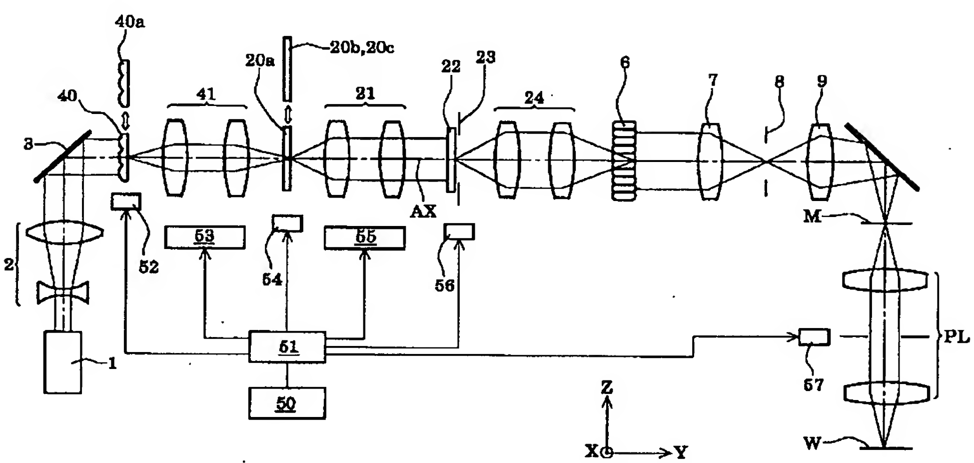
[Drawing 10]



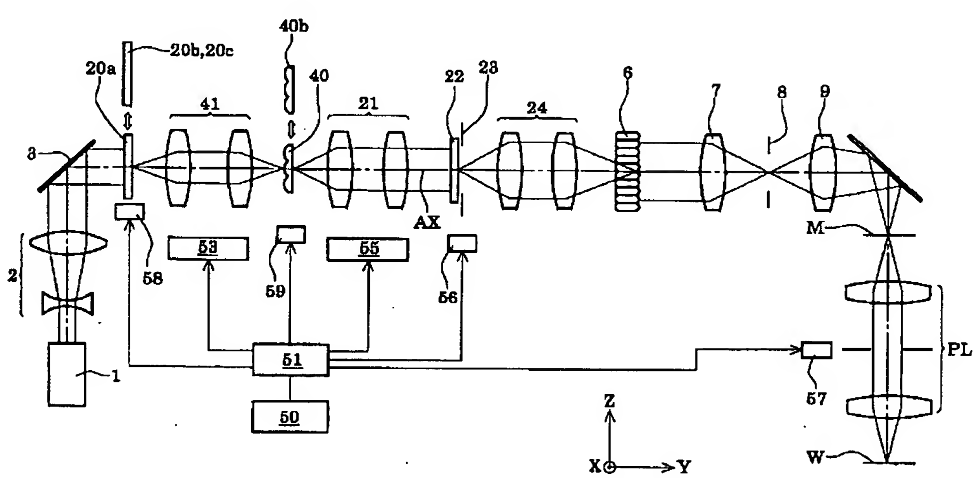
[Drawing 15]



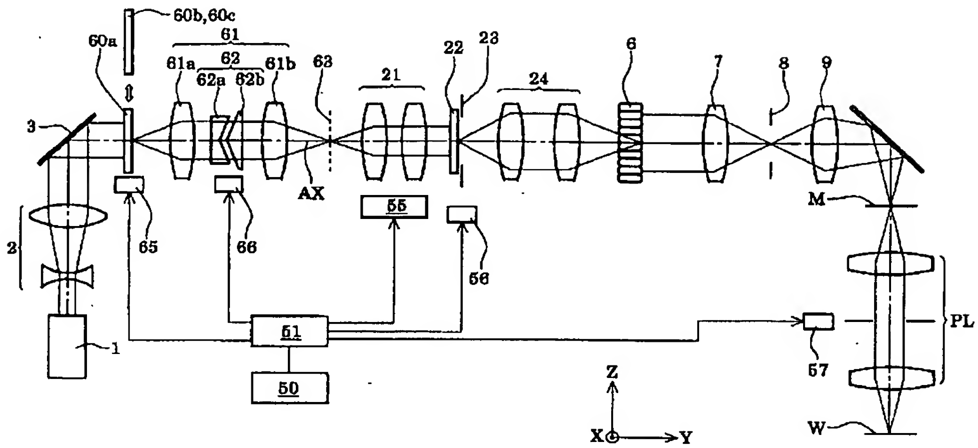
[Drawing 11]



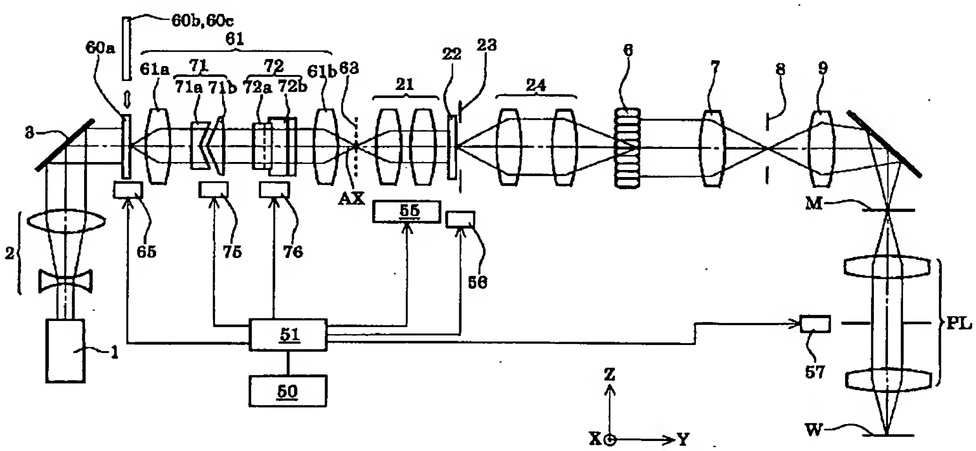
[Drawing 12]



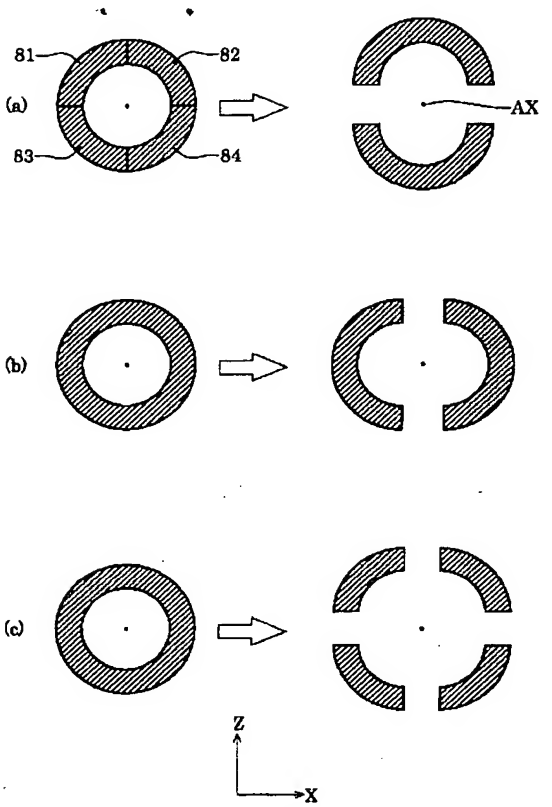
[Drawing 13]



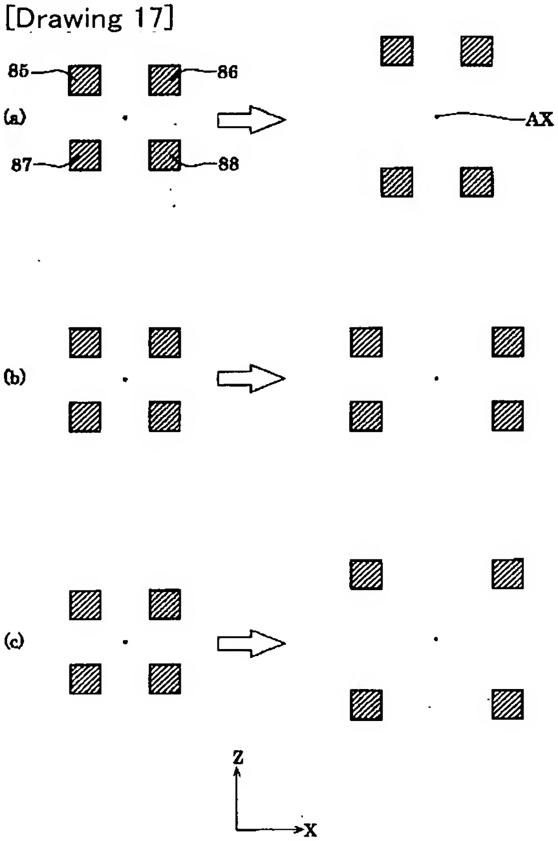
[Drawing 14]



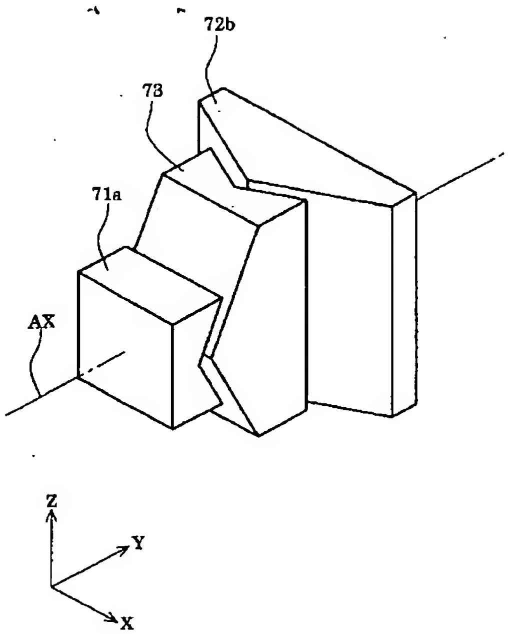
[Drawing 16]



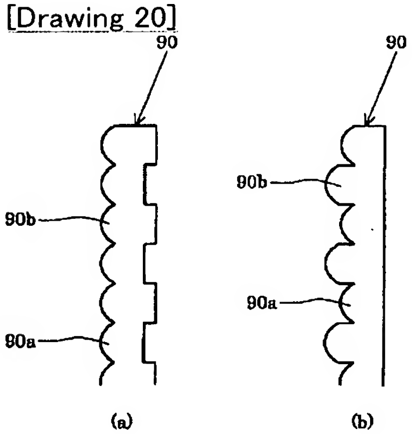
[Drawing 17]



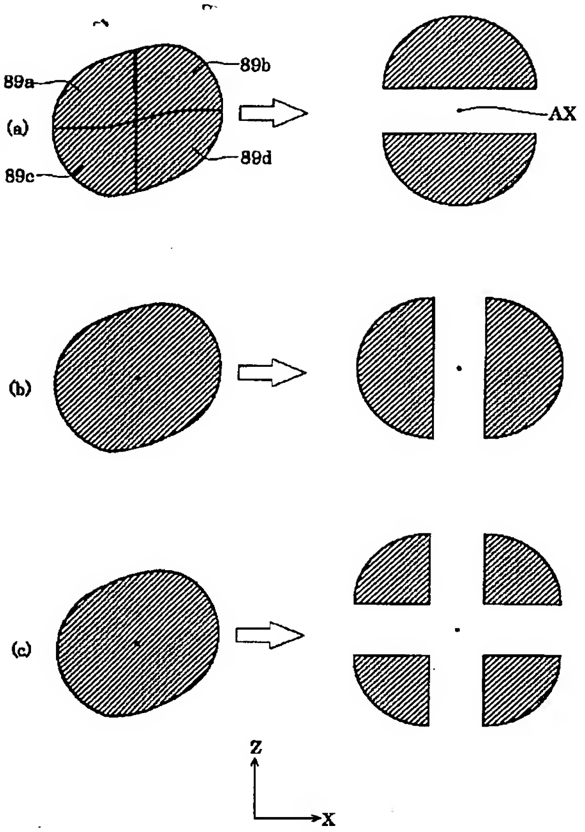
[Drawing 19]



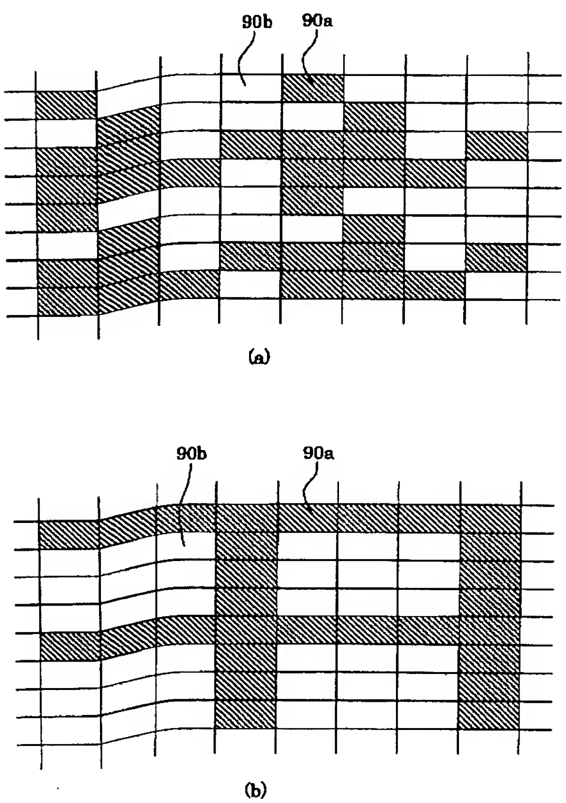
[Drawing 20]



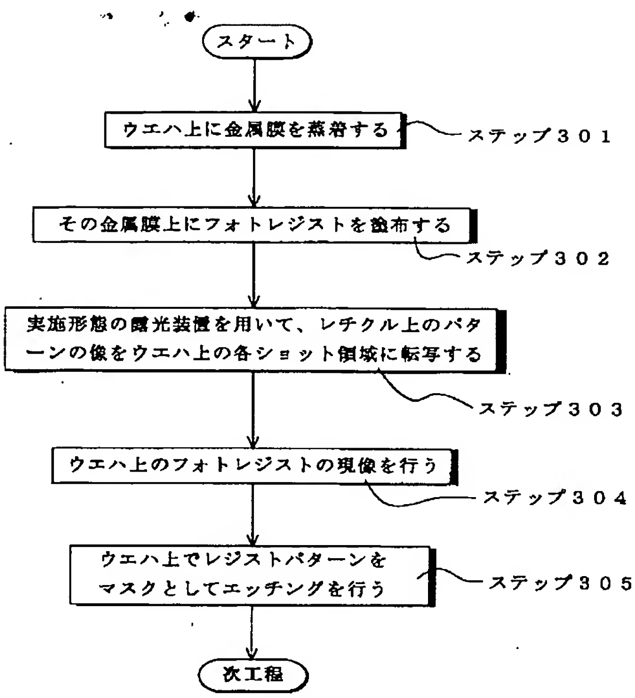
[Drawing 18]



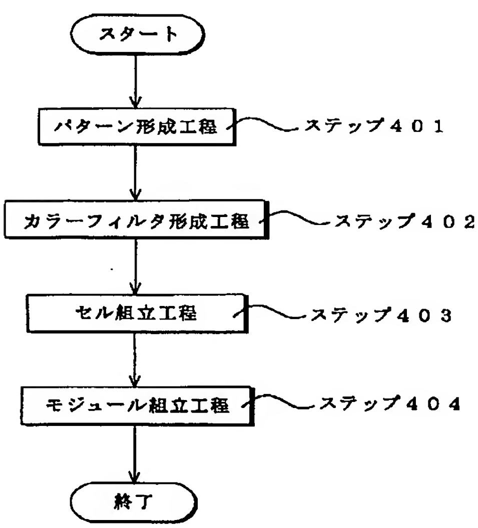
[Drawing 21]



[Drawing 22]



[Drawing 23]



[Translation done.]